JOURNAL OF ECONOMIC ENTOMOLOGY

Official Organ American Association of Economic Entomologists

Vol 43 June, 1950 No. 3

CONTENTS

Toxicity of Phosphorus Compounds to Various Insects ..... W. J. MAGEE and J. C. GAINES 281

Evaluation of Dusting and Spraying Schedules for Cotton Insect Control ..... J. C. GAINES and READ WIPPRECHT 286

Tests of Insecticides for Control of Cotton Insects During 1949 ..... R. L. HANNA and J. C. GAINES 288

Spraying and Dusting for Cotton Insect Control ..... F. A. FENTON 292

Organic Insecticides for Control of Green June Beetle Larvae .. C. B. DOMINICK 295

Residues on Citrus Trees in Florida: Changes in Purple Scale and Rust Mite Populations Following Use of Various Spray Materials ..... J. T. GRIFFITHS and FRAN. E. FISHER 298

Entomogenous Fungi Attacking Scale Insects and Rust Mites on Citrus in Florida ..... FRAN. E. FISHER 305

Orchard Mite Control Experiments in Western New York ..... P. J. CHAPMAN and S. E. LIENK 309

DDT and Some of the Newer Insecticides for Control of Peach Tree Borers ... OLIVER I. SNAPP 315

A Radiobiological Study of Four Organic Phosphates ..... C. C. ROAN, H. E. FERNANDO and C. W. KEARNS 319

Development of Gypsy Moth Sex-Attractant Traps ..... EMORY D. BURGESS 325

Effect of Dichlorodiphenyl Dichloroethane on Larvae of the Clear Lake Gnat in California ..... A. W. LINDQUIST and A. R. ROTH 328

Toxicity of Organic Insecticides to Honeybees: Stomach Poison and Field Tests ..... NEVIN WEAVER 333

Absorption and Translocation of Insecticides Through the Root Systems of Plants ..... ORDWAY STARNES 338

Residual Toxicity of Chemicals for Black Widow Spider Control ..... DEANE P. FURMAN and HASIP KURTPINAR 343

Control of Adult Mosquitoes in Alaska with Aerial Sprays ..... F. S. BLANTON, B. V. TRAVIS, NELSON SMITH and C. N. HUSMAN 347

Control of Mosquito Larvae in Alaska with DDT ..... B. V. TRAVIS, K. H. APPLEWHITE and NELSON SMITH 350

Field Tests with Mosquito and Sand Fly Repellents in Alaska ..... K. H. APPLEWHITE and CARROLL N. SMITH 353

Acute Toxicity of Chlorinated Insecticides Applied to Livestock ..... R. D. RADELEFF and R. C. BUSHLAND 358

Control of Corn Earworm on Sweet Corn in Northern California ..... Oscar G. Bacon 364

Piperonyl Butoxide and Pyrethrins to Control Rice Weevils ..... Carl N. Watts and Francis D. Berlin 371

Control of Alfalfa Weevil in Hay Alfalfa with DDT Dust ..... F. V. Lieberman, S. J. Snow and C. J. Sorenson 374

Red Mite Control on Avocados and Mangos ..... D. O. Wolfenbarger 377

Eretmocerus serius as a Parasite of the Citrus Blackfly in Mexico ..... J. G. Shaw 380

Scientific Notes:

Environmental Resistance as a Factor in Codling Moth Control on Walnuts ..... A. E. Michelbacher, W. W. Middlekauff and Donald Davis 383

Insecticide Tests with Cabbage Caterpillars ..... L. E. Dills and M. L. Odland 384

The Sugar-Cane Rhinoceros Beetle ..... George N. Wolcott 385

On the Host-Ectoparasite Relation ..... Leo Kartman 385

Oncopeltus fasciatus Reared for Laboratory Testing on Watermelon Seeds ..... A. O. Lea and R. E. Niswander 386

Oil Emulsion to Control Rhodes Grass Scale ..... George P. Wene and Paul T. Riherd 386

The Blueberry Flea Beetle ..... F. R. Shaw, J. S. Bailey and E. H. Wheeler 387

Screw-Worm Survey in Western United States, 1949 ..... E. W. Laake 387

Brussels Sprouts Seed Loss in California Caused by the Cabbage Seed Pod Weevil ..... Elmer C. Carlson, W. Harry Lange, Jr. and R. H. Sciaroni 389

Unpublished Data of George Ware Barber on the House Fly ..... Eleanor B. Starnes 390

Influence of Sound Kernels Compared with Halved Kernels of Wheat upon Oviposition of the Rice Weevil ..... D. Bap Reddy 390

A New Insecticide to Control Turf Insects ..... J. B. Polivka 391

Spinose Ear Tick in Florida ..... Andrew J. Rogers and T. W. Mills 392

Relative Toxicity to House Flies of DDT, Methoxychlor, and Dichlorodiphenyl Dichloroethane ..... R. H. Nelson, W. A. Gersdorff and Norman Mitlin 393

Control of the Iris Whitefly on Potatoes ..... K. E. Gibson and B. J. Landis 394

Potato Tuberworm Control in Southern California ..... Lauren D. Anderson and Harold T. Reynolds 396

A Mite Infestation of the Honey Locust ..... Donald L. Schuder 397

Tests on Elm Scolytus, 1949 ..... Stanley W. Bromley 397

Forbes Scale as a Major Pest of Peach ..... S. C. Chandler 398

Dragon Fly Feeding on Cankerworms ..... S. W. Bromley 398

Editorial: Controlling Insect Pests Through Their Nutritional Requirements ..... Leonard Haseman 399

Book Reviews 401

Notes 402

Proceedings Fifth Annual Meeting, North Central States Branch 403

Obituaries 405

WANTED: February, April, and June 1949 Numbers

The Association will pay 60¢ each cash or in a credit for any of the above issues. June numbers needed especially as an entire sack of mail destined for Oregon and Pennsylvania was lost and the Association desires to supply the missing numbers to libraries and individuals who did not get their Journals. Forward to Ernest N. Cory, College Park, Maryland.

JOURNAL OF ECONOMIC ENTOMOLOGY
Official Organ American Association of Economic Entomologists

Vol. 43 June, 1950 No. 3

Toxicity of Phosphorus Compounds to Various Insects[1]

W. J. MAGEE and J. C. GAINES, *Texas Agricultural Experiment Station*

The work summarized by Schrader (1947) showed that a number of organophosphorus compounds possessed outstanding insecticidal properties. Three of these compounds hexaethyl tetraphosphate, tetraethyl pyrophosphate, and parathion have been widely used in experimental work. These compounds have been of particular interest because of their remarkable property of being highly toxic to certain insects, especially aphids and red spider mites. Unfortunately, these compounds are also highly toxic to warmblooded animals and entomologists have not generally recommended some of them because of the danger involved in their use. For this reason, efforts have been made to develop a phosphorus compound which would be non-toxic to higher animals without losing its insecticidal efficiency. The materials used in this study are the result of such efforts. Toxicity tests have shown that some of these compounds have a much lower order of toxicity to high animals than either parathion or tetraethyl pyrophosphate.

The laboratory and field tests herein reported were conducted near College Station, Texas, during 1949. The purpose of this study was (1) to compare the toxicity in the laboratory of seven new phosphorus compounds to: grasshoppers, cotton fleahopper, squash bug, bollworm, boll weevil, aphids and red spider mites using parathion and toxaphene as standard insecticides, and (2) to determine the effectiveness of two of the compounds when used in field tests against several economic insect pests of cotton.

LABORATORY TESTS.—*Methods.*—The phosphorus compounds mentioned above are furnished by the manufacturer as technical compounds, some liquids and some crystalline materials, in a state of almost 100 per cent purity. A 10 per cent dust concentrate was made by dissolving the technical product in acetone then spraying this solution into an airtight metal drum containing pyrophyllite. The drum was revolved while spraying to obtain a thorough mixture. The acetone was allowed to evaporate and the insecticide was thoroughly mixed in a mortar while dry. Lower concentrations were made from the dust concentrate by dilution with pyrophyllite.

The dusting cylinders, atomizers, air pumps and cages used in the laboratory tests were similar to those described by Gaines & Dean (1949). Except where indicated, survival records were taken every 24 hours for a period of 5 days. The number of untreated check cages included in each tests was the same as the number of replicates treated with each dosage of insecticide. Field collected insects were used in all tests except those on bollworms where laboratory reared larvae were used.

GRASSHOPPER TESTS.—Grasshopper nymphs, *Melanoplus differentialis* (Thos.), were used in these tests to show both contact and stomach poison action of the phosphorus compounds. The procedure used to conduct these tests was similar to that described by Gaines & Dean (1948). The results of these tests are shown in tables 1 and 2. To test for contact poison action, approximately 25 second and third to fourth instar grasshopper nymphs were placed in screen wire cages and dusted with a measured amount of insecticide. The dust was allowed to settle for 30 seconds. Immediately after treatment the nymphs were transferred to cages containing clean food and survival records were taken at the end of 48 hours. Approximately 100 nymphs were used to calculate the percentage control. Parathion at 2 per cent strength gave better control than any of the other materials used.

[1] Technical Contribution No. 1301, Texas Agricultural Experiment Station. Research Project supported by American Cyanamid Company.

In the tests for stomach poison action, 15 fourth and fifth instar nymphs were placed on cotton plants previously dusted with a 2 per cent dust which had been allowed to settle for 5 minutes. Approximately 30 insects were used to calculate the percentage control. It was noted that the plants treated at the lower dosage were completely devoured by the nymphs before the end of the test period. For this reason, the number of insects used per cage was reduced to 10 when these tests were duplicated at the higher dosage of 5 per cent. It will be noted in table 2 that the mortalities of all the materials except parathion and compound *3885*[1] are lower at the higher strengths. This was probably due to the repellent action of these compounds which caused the insects to consume less food. For this reason, further testing on grasshopper nymphs was discouraged and the percentage controls were calculated on the basis of only 20 individuals. Parathion was the only material that gave effective control of grasshopper nymphs when used as principally a stomach poison.

COTTON FLEAHOPPER TESTS.—In these tests, table 1, cotton plants were dusted with a measured dose of insecticide and caged immediately after the insecticide had been allowed to settle for 5 minutes. Approximately 30 adult cotton fleahoppers, *Psallus seriatus* (Reut.), were released in each cage. Survival records were taken at the end of 4, 16, and 24 hours. The percentage control was calculated from 180 individuals. Materials *3677*,[1] *3700*[1] and parathion were highly effective against this pest at 2 per cent strength.

SQUASH BUG TESTS.—Approximately 25 fourth and fifth instar squash bug nymphs, *Anasa tristis* (DeGeer), were placed in screen wire cages and dusted with a measured amount of insecticide. The insecticide was allowed to settle 30 seconds. Immediately after settling, the nymphs were placed in cages and fed on clean food throughout the observation period. Approximately 100 individuals were used to calculate the percentage control. The results of these tests are shown in table 1.

Material *3677*[1] appeared promising in the above test and was used on 100 adult squash bugs at 10 per cent strength in a similar test. A percentage control of 71.0 was obtained when this material was applied as a dust at the rate of 25 pounds per acre.

BOLLWORM TESTS.—In these tests, table 2, cotton plants were dusted with a measured amount of insecticide which was allowed to settle 5 minutes. Immediately after settling the plants were placed in cages and 5 third instar laboratory-reared bollworm larvae, *Heliothis armigera* (Hbn.), were released in each cage. Larvae that had been partially eaten by other larvae or parasitized by microorganisms were not included in the records. Approximately 40 individuals were used to calculate the percentage control at 5 per cent strengths. When used at 5 per cent strengths, parathion was as effective as 20 per cent toxaphene. None of the other materials gave adequate control of this pest at that strength. When the dosage was raised to 10 per cent strengths, the toxicity of several of the compounds was reduced, possibly due to some repellant action exerted by the insecticide causing the insects to consume less food. These tests were discontinued because the low toxicities at 10 per cent strengths discouraged further testing, and because the bollworm culture was becoming highly infested with bacterial diseases.

BOLL WEEVIL TESTS.—These tests were conducted on cotton plants growing in the field. The treated plants were dusted under an aluminum dusting cylinder with a measured dosage of insecticide. The dust was allowed to settle 5 minutes. Immediately after settling the plant was caged and 25 boll weevils, *Anthonomus grandis* Boh., were placed on each plant. Each material was used at varying strengths and approximately 250 individuals were used to calculate the dosage-mortality curve. The dosages were calculated on a pounds of active ingredient per acre basis and converted to logarithms, and the percentage-mortalities were converted to probits for calculating the toxicity curves.

The toxicity curves shown in figure 1 were calculated by the method described by Bliss (1938). The MLD and regression coefficient for each insecticide are shown

[1] 3885 = S-Mercaptoacetylurea 0,0-diethyl dithiophosphate.
3677 = 0,0-diethyl 0-2-chloro-4-nitrophenyl thiophosphate.
3700 = S-tert-butyl mercaptomethyl 0,0-bis-(2-chloroethyl) dithiophosphate.
3456 = 0,0-diisopropyl 0-p-nitrophenyl thiophosphate.
3741 = S-Carbamylmethyl 0,0-diethyl dithiophosphate.
3869 = S-Carbamylmethyl 0,0-dimethyl dithiophosphate.
3901 = S-Merceaptoacetylurea 0,0-dimethyl dithiophosphate.

Table 1.—Contact action, mortality of insects as indicated following dust applications.

TREATMENT	PER CENT CONCENTRATION	RATE LBS./ACRE	PER CENT MORTALITY AFTER 24 HOURS TO: Grasshopper[1]	Fleahopper	Squash Bug[2]	Aphid	Red Spider
Parathion	1	10				94.0	99.4
	2	6	62.6				
	2	8	98.5	98.4			
	5	25			59.4		
0,0-diisopropyl 0-p-nitrophenyl thiophosphate (*3456*)	1	10				30.8[3]	21.7[4]
	2	6	9.4				
	2	8	14.1	65.0			
	5	10					29.2[5]
	5	25			0.0		
0,0-diethyl 0-2-chloro-4-nitrophenyl thiophosphate (*3677*)	1	10				95.2	99.7
	2	6	22.5				
	2	8	0.0	96.5			
	5	25			74.5		
S-tert-butyl mercaptomethyl 0,0-bis-(2-chloroethyl) dithiophosphate (*3700*)	1	10				98.3	76.3
	2	6	14.7				
	2	8	22.8	97.0			
	5	25			12.5		
S-Carbamylmethyl 0,0-diethyl dithiophosphate (*3741*)	1	10				89.0	86.3
	2	6	30.0				
	2	8	21.8	68.9			
	5	25			19.8		
S-Carbamylmethyl 0,0-dimethyl dithiophosphate (*3869*)	1	10				53.5	50.5
	2	6	12.1				
	2	8	30.0	51.5			
	5	25			1.1		
S-Mercaptoacetylurea 0,0-diethyl dithiophosphate (*3885*)	1	10				80.7	87.2
	2	6	23.8				
	2	8	10.5	72.2			
	5	25			0.0		
S-Mercaptoacetylurea 0,0-dimethyl dithiophosphate (*3901*)	1	10				78.6	23.0
	2	6	26.0				
	2	8	0.0	62.3			
	5	25			4.1		
Toxaphene-Sulphur	20–40	25			4.2		

[1] 6 pounds per acre—second instar. Mortality at end of 48 hours. 8 pounds per acre—third and fourth instar. Mortality at end of 48 hours.
[2] Mortality at end of 120 hours.
[3] Calculated on 618 individuals.
[4] Calculated on 293 individuals.
[5] Calculated on 251 individuals.

in table 3. These data show the comparative effect of these materials for principally stomach action. Parathion was more effective than any of the other compounds. No toxicity curve was calculated for material *3456*[1] because a 5 per cent dust of this compound was ineffective at 10 pounds per acre.

APHID TESTS.—The procedure used to conduct these tests, table 1, was similar to that described by Roussel & Gaines (1949). Cotton leaves infested with the cotton aphid, *Aphis gossypii* Glov., were examined for live individuals before and 24 hours after dusting and the numbers recorded. The insecticide was allowed to settle for 30 seconds. Approximately 1700 individuals were used to calculate the percentage control. Materials *3677*,[1] *3700*,[1] *2741*[1] and parathion were highly effective for aphid control when used at 1 per cent concentration.

RED SPIDER MITE TESTS.—These tests

[1] See note 1, page 282 and tables 1, 2 and 3.

were conducted in similar manner to the aphid tests described above. Cotton leaves infested with red spider mites, *Septanychus* sp., were examined for live individuals before and 24 hours after dusting and the numbers recorded. The settling time for the insecticide was 30 seconds. Approximately 1500 individuals were used to calculate the percentage control. The results of these tests are shown in table 1. Material *3677* and parathion at 1 per cent strengths gave better control of this pest than any of the other materials used.

FIELD TESTS.—A field experiment, table 4, was conducted to compare materials *3869*[1] and *3901*[1] and toxaphene for boll weevil and bollworm control. The plats were arranged in randomized blocks, each plat being 14 rows wide and 62 feet long or one-fifteenth acre. Each treatment was replicated 4 times. Replicates 1 and 2 of materials 3869 and 3901 received 4 per cent dusts while replicates 3 and 4 received 1 per cent dusts. Twenty per cent toxaphene was used on all replicates for comparison. The first applications were made on July 8 at which time the weevil infestation averaged 20.3 per cent punctured squares and bollworm eggs were noticeable. Infestation records were made in the usual manner at 5-day intervals. After three aplications had been applied, the records indicated that poor control was being obtained from the phosphorus compounds. Beginning with the fourth application, the rates on replicates 1 and 2 of the plats treated with phosphorus compounds were greatly increased and the materials at a 4 per cent strength were used on replicates 3 and 4. Seven effective applications of all materials were made at approximately 5-day intervals. The yields and infestations indicate that the phosphorus compounds were ineffective while toxaphene reduced the weevil infestation and increased the yield significantly.

SUMMARY.—Results of laboratory cage tests in which the toxicity of 7 new phosphorus compounds were compared with parathion show that in general these newer compounds were less toxic to most of the species of insects used. However, in a few cases the toxicity of several of the newer compounds was equal to the toxic-

[1] See note 1, page 282 and tables 1, 2 and 3.

Table 2.—Stomach action, mortality of insects as indicated following dust applications.

TREATMENT	PER CENT CONCENTRATION	POUNDS PER ACRE	PER CENT MORTALITY AFTER 120 HOURS TO: Grasshopper	Bollworm
Parathion	2	12	53.6	
	5	12	100.0	97.9
0,0-diisopropyl 0-p-nitrophenyl thiophosphate (*3456*)	2	12	11.7	
	5	12	0.0	11.4
	10	12		11.8
0,0-diethyl 0-2-chloro-4-nitrophenyl thiophosphate (*3677*)	2	12	0.0	
	5	12	0.0	14.6
	10	12		29.4
S-tert-butyl mercaptomethyl 0,0-bis-(2-chloroethyl) dithiophosphate (*3700*)	2	12	40.0	
	5	12	0.0	26.1
	10	12		0.0
S-Carbamylmethyl 0,0-diethyl dithiophosphate (*3741*)	2	12	8.7	
	5	12	1.8	15.0
	10	12		23.5
S-Carbamylmethyl 0,0-dimethyl dithiophosphate (*3869*)	2	12	44.0	
	5	12	0.0	7.1
	10	12		0.0
S-Mercaptoacetylurea 0,0-diethyl dithiophosphate (*3885*)	2	12	0.0	
	5	12	33.3	4.7
	10	12		0.0
S-Mercaptoacetylurea 0,0-dimethyl dithiophosphate (*3901*)	2	12	32.7	
	5	12	11.1	4.4
	10	12		7.1
Toxaphene-Sul.	20–40	12		95.7

Table 3.—The median lethal dose and regression coefficients of insecticidal mixtures as indicated below for adult boll weevils.

TREATMENT	MLD POUNDS ACTIVE INGREDIENT PER ACRE	SLOPE (REGRESSION COEFFICIENT)
Parathion	0.1	2.8
0,0-diethyl 0-2-chloro-4-nitrophenyl thiophosphate (*3677*)	0.3	1.8
S-tert-butyl mercaptomethyl 0,0-bis-(2-chloroethyl)dithiophosphate (*3700*)	0.2	2.8
S-Carbamylmethyl 0,0-diethyl dithiophosphate (*3741*)	0.6	1.5
S-Carbamylmethyl 0,0-dimethyl dithiophosphate (*3869*)	0.4	3.9
S-Mercaptoacetylurea 0,0-diethyl dithiophosphate (*3885*)	0.3	0.8
S-Mercaptoacetylurea 0,0-dimethyl dithiophosphate (*3901*)	0.3	2.3

ity of parathion. It was noted that in some instances the higher dosages of the newer compounds resulted in reduced toxicity. This is believed to be due to some repellant action exerted by the insecticide at higher concentrations.

In laboratory cage tests, parathion was found to be more toxic to grasshopper nymphs than any of the other phosphorus compounds when used as a contact poison or as a stomach poison.

The newer phosphorus compounds proved to be less toxic than parathion to the boll weevil.

Five per cent parathion and 20 per cent toxaphene at 12 pounds per acre gave adequate control of the cotton bollworm. The other phosphorus compounds were much less toxic to this pest at 5 per cent and 10 per cent strengths.

A 2 per cent dust applied at the rate of 8 pounds per acre of either *3677*[1] or *3700*[1] was found to be as toxic to adult cotton fleahoppers as a 2 per cent parathion dust applied at the same rate.

Compound *3677*,[1] at 5 per cent strength applied at 25 pounds per acre, gave fair control of squash bug nymphs. Fair control of squash bug adults was also obtained when this material was used at 10 per cent strength.

At 1 per cent concentration, dust of materials 3677,[1] 3700,[1] and 3741[1] when applied at the rate of 10 pounds per acre was found to be as effective as was 1 per cent parathion for controlling the cotton aphid.

A 1 per cent dust of material 3677[1] and parathion were equally toxic to red spider mites when these materials were applied at the rate of 10 pounds per acre.

Materials *3869*[1] and *3901*[1] were not effective in the control of either boll weevils or bollworms under existing field conditions.

Table 4.—The boll weevil infestation, bollworm injury and yield of seed cotton on field test for comparing materials 3869, 3901 and toxaphene at College Station, Texas.

Treatment	Pounds per Acre[1] per Application	Per Cent[2] Boll Infestation	Bollworm Eggs[3]	Per Cent[4] Bollworm Injured Bolls	Pounds Seed Cotton[5]		
					Per Plat	Per Acre	Gain Over Check
Toxaphene-Sulphur (20–40)	18	38.6	4.8	3.6	45.7	1828	572
S-Carbamylmethyl 0,0-dimethyl dithiophosphate (*3869*)	18	58.4	3.4	15.9	28.0	1120	−136
S-Mercaptoacetylurea 0,0-dimethyl dithiophosphate (*3901*)	18	51.6	3.8	15.4	27.8	1112	−144
Check		58.4	3.4	11.4	31.4	1256	
Minimum Significant Difference					12.1		

[1] Average of 7 records made July 8 to August 10.
[2] Average of 6 records made July 7 to August 1.
[3] Average of 6 records made July 7 to August 1.
[4] Average of 7 records made July 18 to August 17.
[5] Picking area one-fortieth acre.

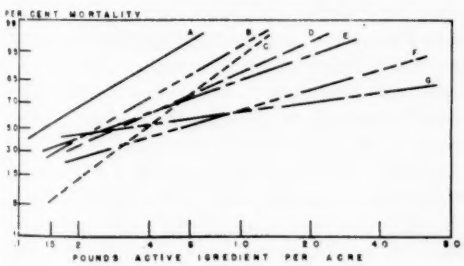

FIG. 1.—Dosage-mortality curves for the toxicity of the following insecticides to the boll weevil: (A) Parathion B) S-tert-butyl mercaptomethyl 0,0-bis-(2-chloroethyl) dithiophosphate (C) S-Carbamylmethyl 0,0-dimethyl dithiophosphate, (D) 0,0-diethyl 0-2-chloro-4 nitrophenyl thiophosphate, (E) S-Mercaptoacetylurea 0,0-dimethyl dithiophosphate, (F) S-Carbamylmethyl 0,0-diethyl dithiophosphate and (G) S-Mercaptoacetylurea 0,0-diethyl dithiophosphate.

[1] See note 1, page 282 and tables 1, 2 and 3.

LITERATURE CITED

Bliss, C. I. 1938. The determination of the dosage-mortality curve from small numbers. Quart. Jour. Phar. and Pharmacology **XXI** (2): 192.

Gaines, J. C., and H. A. Dean. 1948. Comparison of insecticide dusts for grasshopper control. JOUR. ECON. ENT. **41**(6): 945–8.

Gaines, J. C., and H. A. Dean. 1949. Effect of temperature and humidity on the toxicity of certain insecticides. JOUR. ECON. ENT. **42**(3): 429–33.

Roussel, J. S., and J. C. Gaines. 1949. Comparison of calcium arsenates alone and mixed with organic insecticides for cotton insect control. JOUR. ECON. ENT. **42**(3): 551–2.

Schrader, Gerhard. 1947. The development of new insecticides. B.I.O.S. Final Report No. 714 (Revised), Item No. 8.

Evaluation of Dusting and Spraying Schedules for Cotton Insect Control[1]

J. C. GAINES and READ WIPPRECHT, *Texas Agricultural Experiment Station*

Since 1925, early season control of the boll weevil, *Anthonomus grandis* Boh., by either the so-called "Florida method" or the pre-square mopping or dusting methods has been advocated. These practices were practiced by some planters and proved to be more effective in communities where all planters cooperated in the program. However, neither method has been generally accepted by the cotton planters.

The new organic insecticides have proven to be effective both in the form of sprays and dusts against such insects as thrips, aphids, fleahoppers and boll weevils which usually attack cotton early in the season. The control of all these insects appears both practical and promising. It has been demonstrated that early applications of these materials will protect cotton fruit and allow the fruit to set at any time. However, Dunnam (1943), Eaton (1931) and Hamner (1941) demonstrated that the removal of the early produced squares did not reduce the yield. Gaines *et al.* (1947, 1948) reported results of tests which indicated that it was more profitable to dust cotton during the last 3 weeks of July and August with a quick-acting, effective insecticidal mixture, at a time when weevils and bollworms are most injurious, than to try to protect the fruit during the entire season. These tests were conducted in an area in which the bollworm appears almost every year. In other areas in which the bollworm is not considered a pest, it seems possible that the early control of all insects, over large areas, may prove profitable.

Experiments designed to evaluate the different schedules of applications have been conducted at this station since 1946. The summarized results of these tests are in herein presented. All experiments were conducted in the Brazos River bottoms near College Station.

A series of experiments was designed (1) to determine the effect of different dusting schedules and (2) to determine the effect of removing certain numbers of blooms on the yield of cotton. In each experiment, the plats were arranged in randomized blocks, each plat being 12 rows wide and of sufficient length to make one-twentieth acre. Each treatment was replicated 3 times. The treatments, materials, etc., are shown in table 1. During the 3-year period, the plats designated "complete control" received an average of 10 applications, beginning soon after chopping and continued throughout the season. The plats designated "applications as needed" received an average of 7 applications for fleahopper, boll weevil and bollworm control, while the plats designated "late control" received 6 applications during July and August for boll weevil and bollworm control. All plats from which the blooms were removed received continuous applications for complete control of all insects.

All blooms were removed beginning at the time the first bloom was observed throughout the periods as indicated in table 1. The average number of blooms per acre removed during the 22, 25, and 27 day periods were 37,220, 83,300 and 124,560 respectively. These blooms repre-

[1] Technical Contribution No. 1279, Texas Agricultural Experiment Station in cooperation with the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture.

Table 1.—The insecticides used and yields on plats as indicated on experiments conducted at College Station, Texas.

Year	Insecticide Used	Yields, Pounds Seed Cotton per Acre						
		Check	Complete Control	Applications as Needed	Late Control	Blooms Removed for: 22 Days	25 Days	27 Days
1947	3-5-40[1]	1150	1340	1485	1645	1235	1340	1160
1948	20% Toxaphene-40% Sulphur	564	816	620	684	504	496	532
1949	20% Toxaphene-40%Sulphur	1325	2335	2105	2405	1825	1945	1725
Average[2]		1013	1497	1403	1578	1188	1260	1139

[1] 3% gamma benzene hexachloride-5% DDT-40% sulphur.
[2] Min. difference required for significance between any 2 means = 207 lbs.

sented an average estimated loss of 372, 833 and 1246 pounds of seed cotton per acre, respectively, had they been allowed to develop on the plants.

The analysis of variance of each annual experiment indicates that there was no significant difference in the yields of the different treatments. The combined analysis for the 3-year period indicates that there was no significant difference between the plants receiving complete control, applications as needed or the late control. However, removing all blooms for a 22-day period significantly reduced the yields. Insects did not cause a complete destruction of fruit early in the season and the cotton plant compensated for this loss by fruiting later in the season. The plants did not have the power of compensating for a total loss of fruit during a period of 22 days or more.

Another series of experiments was conducted to determine the effect of different dusting and spraying schedules on the yield of cotton. In these experiments, the plats ranged in size from 1 to 5 acres. The schedules materials used, etc., are shown in table 2. During the 4-year period the plats designated "complete control" received an average of 10 applications beginning soon after chopping and continued throughout the season. The plats designated "applications as needed" received an average of seven applications for fleahopper, boll weevil and bollworm control while the plats designated "late control" received five applications during July and August for boll weevil and bollworm control.

The calcium arsenate used in the test conducted during 1947 gave lower yields on the late treated plats than the benzene hexachloride-DDT mixture. The benzene hexachloride-DDT-sulphur gave a quicker control of the weevil and allowed the

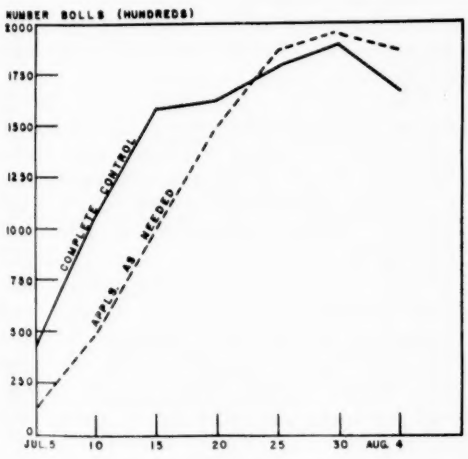

FIG. 1.—The number of bolls per acre on experiments at College Station, Tex.

Table 2.—The insecticides used and yields on plats as indicated on experiments conducted at College Station, Tex.

Year	Insecticide Used	Yield, Pounds Seed Cotton per Acre			
		Check Untreated	Complete Control	Applications as Needed	Late Control
1946	Calcium Arsenate	823	1301	1358	1297
1947	Calcium Arsenate	547	1502	1538	1300
1947	3-5-40[1]	721	1488	1517	1417
1948	3-5-40	412	829	762	528
1948	20% Toxaphene-40% Sulphur	679	1115	681	587
1949	20% Toxaphene-40% Sulphur	1226	1789		1610
1949	Toxaphene Spray	1226	1701		1478
1949	20% Toxaphene-40% Sulphur	730	1766	1533	
1949	3-5-40	730	1772	1597	
1949	20% Toxaphene-40% Sulphur		1927	1736	
1949	Toxaphene Spray[2]		1794	1736	

[1] 3% gamma benzene hexachloride-5% DDT-40% sulphur.
[2] Toxaphene spray applied early in season, toxaphene dust used later in season.

cotton to fruit in a minimum of time. In an extremely dry year, 1948, the yields were lower on the plats receiving late treatments for control. In the other years in which the rainfall was at least normal, the yields were about the same on plats receiving complete control, applications as needed or late control. The toxaphene spray was not as effective as the toxaphene dust when used to control the boll weevil after migration.

The number of bolls per acre was recorded on 4 plats during 1949, (Fig. 1), at 5-day intervals to determine the difference in the rate of fruit production from the 2 schedules of applications. The early season applications allowed the plants to set bolls approximately 5 days earlier than those receiving later applications. However, by July 25 the plants on those plats receiving the late applications had set as much fruit as the plants on those plats receiving the early applications. The final yields were approximately the same.

Under the conditions of these experiments, it is apparently more economical to apply insecticides for the control of injurious populations of insects (as needed) than to apply applications early in the season plus the necessary later applications to protect the crop from weevils and bollworms.

LITERATURE CITED

Dunnam, E. W. J. C. Clark and S. L. Calhoun. 1943. Effect of the removal of squares on yield of upland cotton. JOUR. ECON. ENT. **36**(6): 896–900.

Eaton, Frank M. 1931. Early defloration as a method of increasing cotton yields, and the relation of fruitfulness to fiber and boll characters. Jour. Agr. Res. **42**(8): 447–62.

Gaines, J. C., W. L. Owen, Jr., and Read Wipprecht. 1947. Effect of dusting schedules on the yield of cotton. JOUR. ECON. ENT. **40**(1): 113.

Gaines, J. C., and Read Wipprecht. 1947. Effect of dusting schedules on the yield of cotton during 1947. JOUR. ECON. ENT. **41**(3): 410.

Hamner, A. L. 1941. Fruiting of cotton in relation to cotton fleahopper and other insects which do similar damage to squares. Miss. Agr. Expt. Sta. Bul. **360**: 1–11.

Tests of Insecticides for Control of Cotton Insects During 1949[1]

R. L. HANNA and J. C. GAINES, *Texas Agricultural Experiment Station*

Investigations were conducted at this Station to determine the efficiency of some of the newer insecticides and insecticidal combinations in the control of the boll weevil, *Anthonomus grandis* Boh., bollworm, *Heliothis armigera* Hbn., and cotton aphid, *Aphis gossypii* Glov.

Recent development of a special calcium arsenate (lime free) has made possible the combination of calcium arsenate with organic insecticides. Tests to evaluate the merits of these special calcium arsenate mixtures seemed desirable. In previous experiments on the control of the boll weevil and bollworm, these mixtures have prevented aphid increases. Work on combinations of this type has been reported by Ewing *et al.* (1947), Dunnan & Calhoun (1948), Roussel & Gaines (1949) and Gaines & Dean (1949). The tests using mixtures containing calcium arsenate herein reported were a continuation of previous work done at the Texas Station. Also included in these experiments were two of the newer organic compounds. The insecticidal mixtures commonly used for cotton insect control were included in the tests for comparison.

The percentages of boll weevil punctured squares and bollworm injured bolls were transformed to angles for variance analysis.

Experiment 1, as shown in table 1, was conducted to determine the effectiveness of the following materials against the boll weevil and bollworm: (1) special calcium arsenate-0.5 per cent parathion, (2) special calcium arsenate-0.5 per cent gamma benzene hexachloride, (3) special calcium arsenate-1 per cent gamma benzene hexachloride and (4) 20 per cent toxaphene-40 per cent sulphur. Another objective was to determine the effectiveness of the organics when mixed with special calcium arsenate as a preventive

[1] Technical Contribution No. 1280, Texas Agricultural Experiment Station in cooperation with the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture.

Table 1.—The average boll weevil infestation, bollworm injury and yields of seed cotton on experiment 1 at College Station, Texas.

Treatment	Boll Weevil Infestation		Bollworm Injury		Yield		
	Per Cent Sqs. Punct.	Angles	Per Cent Inj. Bolls	Angles	Per Plat	Per Acre	Gain Over Check
20% Toxaphene-Sulphur	30.0	33.2	3.5	10.6	88.6	2215	1185
Sp. Cal. Arsenate 0.5% Parathion	21.0	27.2	6.8	13.4	87.4	2185	1155
Sp. Cal. Arsenate 1% G. BHC	25.9	30.6	4.8	12.8	84.5	2110	1080
Sp. Cal. Arsenate 0.5% BHC	21.7	27.8	6.1	14.4	87.9	2197	1167
Check	59.7	50.7	20.7	27.4	41.2	1030	
Min. diff. req. for sig.		3.6		4.7	12.3		

against the development of aphid infestations. A randomized block plat arrangement was used. Each plat was 14 rows wide and 113 ft. long or approximately one eighth acre. Each treatment was replicated four times. Infestation records were made in the usual manner from July 5 to August 3. Eight applications of insecticides were made at 5-day intervals from July 6 to August 11 at an average rate of 13 pounds per acre.

Boll weevil infestation in this experiment averaged approximately 30 per cent punctured squares on July 5. The infestation had increased to 60 per cent by July 20 and remained high for the entire season. Bollworm oviposition reached its peak in the middle of July and continued through the first part of August. Both boll weevil and bollworm caused severe damage to the untreated plats.

The special calcium arsenate-0.5 per cent parathion and the special calcium arsenate-0.5 per cent gamma benzene hexachloride were more effective against the boll weevil than the 20 per cent toxaphene-40 per cent sulphur. There was no significant difference in the effectiveness of any of the insecticides for bollworm control. All treatments yielded at least twice as much seed cotton as the untreated checks but there was no significant difference in yield between any of the treatments.

None of the materials produced injurious aphid or red spider infestations.

Experiment 2, as shown in table 2, was designed to compare the effectiveness of (1) special calcium arsenate-0.5 per cent parathion, (2) special calcium arsenate-1 per cent gamma benezene hexachloride, (3) 20 per cent toxaphene-0.5 per cent parathion and (4) 20 per cent toxaphene-40 per cent sulphur against the boll weevil and bollworm in an effort to determine whether or not the special calcium arsenate mixtures would prevent increased aphid infestations. A randomized block plat arrangement was used. Each plat was 14 rows wide and of sufficient length to make one-ninth acre. Each treatment was replicated 4 times. Infestation records were made at 5-day intervals from June 23 to July 26. Seven applications of insecticides were made from June 24 to July 30 at an average rate of 14 pounds per acre.

The boll weevil infestation averaged

Table 2.—The average boll weevil infestation, bollworm injury, and yields of seed cotton on experiment 2, at College Station, Texas.

Treatment	Boll Weevil Infestation		Bollworm Injury		Yield		
	Per Cent Sqs. Punct.	Angles	Per Cent Inj. Bolls	Angles	Per Plat	Per Acre	Gain Over Check
Sp. Cal. Arsenate 0.5% Parathion	17.9	24.6	5.9	14.0	97.30	1946	739
Sp. Cal. Arsenate 1% γ BHC	15.8	23.3	4.3	12.5	83.65	1673	466
Toxaphene-Parathion (20–0.5)	13.8	21.5	3.9	10.6	95.32	1906	699
Toxaphene-Sulphur (20–40)	13.5	21.2	1.7	8.1	87.50	1750	543
Check	27.4	30.9	11.0	19.1	60.35	1207	
Min. diff. req. for sig.		5.2		4.4	22.2		

Table 3.—The average boll weevil infestation, bollworm injury, and yields of seed cotton on experiment 3, at College Station, Texas.

Treatment	Boll Weevil Infestation		Bollworm Injury		Yield		
	Per Cent Sqs Punct.	Angles	Per Cent Inj Bolls	Angles	Per Plat	Per Acre	Gain Over Check
Calcium Arsenate 1% γ. BHC	11.7	19.55	5.5	13.55	80.95	1619.0	499.4
Toxaphene Sulphur (20–40)	11.4	19.32	3.5	10.65	86.10	1722.0	602.4
3% γ BHC-5% DDT-40% Sulphur	10.9	18.84	3.0	9.90	85.28	1705.6	586.0
Dieldrin-Sulphur (5–40)	7.6	15.93	2.5	9.18	83.00	1660.0	540.4
Check	22.0	28.08	13.2	21.23	55.98	1119.6	
Min. dif. req. for sig.		7.9		2.4	17.66		

about 30 per cent punctured squares on June 23 and persisted throughout the season at an injurious level. Bollworm oviposition was continuous throughout the season but was greatest during the last half of July.

All materials were equally effective against the boll weevil. The toxaphene-sulphur was slightly more effective against the bollworm than the two calcium arsenate mixtures. When yields were used as the criterion, all treatments were equally effective.

Injurious infestations of aphids or red spiders did not develop on any of the plats.

Experiment 3, as shown in table 3, was identical in design with experiment 2 and adjacent to it. Therefore, the insect infestations were practically the same. The materials tested in experiment 3 were (1) special calcium arsenate-1 per cent gamma benzene hexachloride, (2) 5 per cent dieldrin-40 per cent sulphur, (3) 3 per cent gamma benzene hexachloride-5 per cent DDT-40 per cent sulphur and (4) 20 per cent toxaphene-40 per cent sulphur.

Table 4.—The average boll weevil infestation, bollworm injury, and yields of seed cotton on experiment 4, at College Station, Texas.

Treatment	Boll Weevil Infestation	Bollworm Injury	Yield	
	Per Cent Punct. Sqs.	Per Cent Inj. Bolls	Per Acre	Gain Over Check
Sp. Cal. Arsenate .5% Parathion	24.3	2.1	2200	998
2.5% Aldrin-inert	48.0	7.0	1872	670
20% Toxaphene-40% Sulphur	34.8	3.0	2235	1033
Check	87.2	7.6	1202	

All four materials were equally effective against the boll weevil. Toxaphene-sulphur, benzene hexachloride-DDT-sulphur and dieldrin-sulphur were more effective against the bollworm than was the special calcium arsenate-benzene hexachloride mixture. This difference was not enough, however, to affect the yields. There was no significant difference in yield between any of the treatments.

There was no injurious increase of aphids or red spiders on any of the plats.

Experiment 4, as shown in table 4, was a non-replicated comparison of (1) special calcium arsenate-0.5 per cent parathion, (2) 2.5 per cent aldrin and (3) 20 per cent toxaphene-40 per cent sulphur. The area treated with each insecticide was 14 rows wide 113 ft. long or approximately one-eighth acre. An untreated plat of the same area was included in the comparison. Seven applications of aldrin were made from July 11 to August 11 at an average rate of 17 pounds per acre. Eight applications of calcium arsenate-parathion and toxaphene-sulphur were made from July 6

Table 5.—The average boll weevil infestation, bollworm injury. and yields of seed cotton on experiment 5, at College Station, Texas.

Treatment	Boll Weevil Infestation	Bollworm Injury	Yield	
	Per Cent Punct. Sqs.	Per Cent Inj. Bolls	Per Acre	Gain Over Check
Sp. Cal. Arsenate .5% BHC	13.1	9.7	1217.4	486.6
20% Toxaphene-40% Sulphur	12.3	4.3	1533.7	802.9
3% γ BHC-5% DDT-40% Sulphur	14.6	8.5	1597.8	867.0
Check	42.0	18.4	730.8	

to August 11 at an average rate of 13 pounds per acre.

Boll weevil infestation was exceptionally high throughout the period covered by the experiment. Bollworm infestation was also rather heavy.

Percentages of punctured squares and injured bolls were lower in the toxaphene-sulphur and calcium arsenate-parathion treated plats than in the plat treated with aldrin. The yield of the toxaphene-sulphur and calcium arsenate-parathion treated plats was considerably higher than in the plat treated with aldrin.

None of the plats developed injurious infestations of aphids or red spiders.

Experiment 5, as shown in table 5, was a comparison of (1) special calcium arsenate-0.5 per cent gamma benzene hexachloride, (2) 3 per cent gamma benzene hexachloride-5 per cent DDT-40 per cent sulphur and (3) 20 per cent toxaphene-40 per cent sulphur. Five-acre plats were used and a 5-acre untreated plat was included.

The treatments were not replicated. Infestation records were made at three points in each plat at 5-day intervals from July 6 to August 1. Four applications of insecticide were made with a tractor duster from July 7, to July 23. The first application was at the rate of 10 pounds per acre and the last at the rate of 15 pounds per acre.

Boll weevil infestation averaged about 40 per cent punctured squares on the untreated plat during the period covered by the experiment. Bollworm oviposition reached a peak of 22 eggs per hundred terminals by the middle of July.

All materials were effective against the boll weevil. The special calcium arsenate-benzene hexachloride mixture did not control the bollworm as well as the toxaphene-sulphur. The yields were higher on the plats treated with the organic insecticides than on the plat treated with the special calcium arsenate-benzene hexachloride mixture.

SUMMARY.—Special calcium arsenate-0.5 per cent parathion, special calcium arsenate-0.5 per cent gamma benzene hexachloride, special calcium arsenate-1 per cent gamma benzene hexachloride and 20 per cent toxaphene-40 per cent sulphur were used against boll weevils and bollworms in a randomized block experiment. Calcium arsenate-0.5 per cent parathion and calcium arsenate-0.5 per cent gamma benzene hexachloride were more effective against the boll weevil than the toxaphene-sulphur. However, there was no significant difference in yield between any of the treatments.

Special calcium arsenate-0.5 per cent parathion, special calcium arsenate-1 per cent gamma benzene hexachloride, 20 per cent toxaphene-0.5 per cent parathion and 20 per cent toxaphene-40 per cent sulphur were tested against the same insects in a second randomized block experiment. Toxaphene-sulphur was more effective against the bollworm than the calcium arsenate mixtures, but there were no significant differences in yield.

Special calcium arsenate-1 per cent gamma benzene hexachloride, 5 per cent dieldrin-40 per cent sulphur, 3 per cent gamma benzene hexachloride-5 per cent DDT-40 per cent sulphur and 20 per cent toxaphene-40 per cent sulphur were used for control of boll weevils and bollworms in a third randomized block experiment. The three organic insecticides gave better control of the bollworm than did the special calcium arsenate mixture. There was no significant difference in yield following the treatments.

These three experiments indicated that the calcium arsenate mixtures used were slightly more effective against the boll weevil than were the organic insecticides used while the organic insecticides were slightly more effective than the calcium arsenate mixtures against the bollworm. When yields were used as the criterion, all the materials were equally effective in controlling both boll weevil and bollworm infestations.

A non-replicated small plat comparison was made of special calcium arsenate-0.5 per cent parathion, 2.5 per cent aldrin and 20 per cent toxaphene-40 per cent sulphur. This comparison indicated that aldrin was not as effective against the bollworm and boll weevil as the toxaphene-sulphur and the calcium arsenate-parathion.

A comparison of special calcium arsenate-0.5 per cent gamma benzene hexachloride, 3 per cent gamma benzene hexachloride-5 per cent DDT-40 per cent sulphur and 20 per cent toxaphene-4 per cent sulphur was made using five-acre plats.

The organic insecticide mixture produced higher yields than the special cal-

cium arsenate mixture due to better bollworm control.

The addition of parathion or benzene hexachloride to the special calcium arsenate was effective in preventing aphid increases in all experiments.

LITERATURE CITED

Dunnam, E. W., and S. L. Calhoun. 1948. Benzene hexachloride to control boll weevils and cotton aphids in 1946. JOUR. ECON. ENT. **40**(4): 508.

Ewing, K. P., C. R. Parencia, Jr., and E. E. Ivy. 1947. Cotton insect control with benzene hexachloride alone or in a mixture of DDT. JOUR. ECON. ENT. **40**(3): 347.

Gaines, J. C., and H. A. Dean. 1949. Insecticide tests for boll weevil control during 1948. JOUR. ECON. ENT. **42**(3): 429–33.

Roussel, J. S., and J. C. Gaines. 1949. Comparison of calcium arsenates alone and mixed with organic insecticides for cotton insect control. JOUR. ECON. ENT. **42**(3): 551.

Spraying and Dusting for Cotton Insect Control

F. A. FENTON, *Oklahoma A. & M. College, Stillwater*

The possibility of controlling boll weevils and other cotton insects by spraying was studied in four fields near Canadian, Oklahoma, in 1949. The spray was prepared by diluting with water an emulsifiable concentrate containing 40 per cent technical toxaphene and 20 per cent technical DDT. The sprayer was of the low-volume type and was mounted on a trailer pulled by a tractor. The gear pump was powered by the tractor and operated at 60 pounds pressure in two fields and at 80 pounds in one field. The amount of spray used per acre varied from 2.5 gallons in small cotton at 60 pounds up to 8.5 gallons per acre in tall cotton at 80 pounds. The spray was delivered from a boom attachment so that six rows were sprayed at a time. One nozzle per row was used in small cotton; the spray being directed to the tops of the plants from a distance of about 6 inches. When two nozzles were used per row, the spray was directed to the sides of the plants in such a way that both the tops and sides were covered. When three nozzles were used the extra nozzle directed the spray to the tops of the plants. The nozzle used was of the conical T-jet type and delivered a cone-shaped spray that produced a very fine mist which appeared to envelop the plants. The diameter of the spray droplets at 60 pounds ranged from 40 to 80 microns. Spraying was done during the day under conditions of moderate air movement which would have been decidedly unfavorable for dusting. On only one occasion was it considered too windy to spray.

Comparisons were made with plots which were dusted with four dust formulations, some of which had been previously tested and found to be very effective against boll weevils and bollworms.

These were a mixture containing 3 per cent gamma benzene hexachloride, 5 per cent DDT and 40 per cent sulfur, a mixture containing 20 per cent toxaphene and 40 per cent sulfur and two calcium arsenate formulations. Both of the latter contained 1 per cent gamma benzene hexachloride and in addition one contained 5 per cent DDT. The dusts were applied with a 6-row power duster mounted on a trailer which was pulled by a tractor. From 8 to 15 pounds were applied per acre at each application.

The effectiveness of each treatment was determined by square and boll infestation counts for boll weevils and bollworms, and by yields. Each field was planted to a different variety. These were Stoneville 62-B, Coker 100 and Improved Rowden.

Boll weevil infestation was exceedingly heavy. There were a few flea hoppers present early in the season. Bollworms invaded the fields late in July. In one field they caused considerable injury. A heavy cotton aphid infestation developed in the plots which were dusted with the calcium arsenate formulations. Rainfall was adequate for good cotton growth up to mid-June but from then on very little precipitation occurred except on one of the four fields under observation. Drouth definitely reduced yields in one field (Test Number 1) and also reduced the differences between the treated and check plots in this field.

Table 1.—Treatment, average per cent infestation and yields in sprayed and dusted cotton. Moncrief Farm, Canadian, Oklahoma, 1949.

Treatments					Avg. Per Cent Boll Weevil		Pounds Seed Cotton
	Avg. Lbs. per Acre per Application			Dates Applied			
Formulation	γ-BHC	DDT	Toxaphene		Squares	Bolls	Per Acre[1]
3-5-40 dust	0.40	0.67	—	6/16, 23, 27; 7/13, 21, 28	23.6	9.9	1276
3-5-40 dust	0.32	0.53	—	6/23, 27; 7/13, 21, 28	32.4	11.7	1248
20-40 dust	—	—	2.6	6/16, 23, 27; 7/13, 21, 28	22.8	11.5	1235
DDT-Toxaphene spray	—	0.9	1.8	6/15, 22; 7/13, 18, 28	21.6	9.3	1212
DDT-Toxaphene spray	—	0.9	1.8	6/15, 22; 7/13, 18	23.3	12.3	1238
DDT-Toxaphene spray	—	0.8	1.6	6/8; 7/13, 18	30.2	12	1184
Checks	—	—	—	—	44.3	28	957

[1] Yields of treated plots not significantly different statistically.

RESULTS.—*Test Number 1.*—The cotton in this test was planted April 29–30 and was the Stoneville 62-B variety. The field of 29 acres in area was fertilized with 4-12-4 at approximately 300 pounds per acre. The west two-thirds of this field was divided into plots for treatment that varied from 0.83 to 0.91 acre in size. Each plot consisted of 12 rows. There were 3 dust treatments and 3 spray treatments in a randomized block design with each treatment replicated 4 times. The data were analyzed statistically according to the analysis of variance method.

There was no significant difference in yields or grade of cotton picked in the plots sprayed or dusted (Table 1). No advantage was obtained by using 15 pounds of the 3-5-40 dust mixture per acre per application for the last three treatments over using 10 pounds for these treatments. There were no significant differences in yields between plots sprayed 3, 4 and 5 times. Likewise, the yields in the plots dusted with the 20–40 mixture were not significantly different from those dusted with the 3-5-40 mixture. The yields in the plots sprayed once during the pre-square stage of cotton were not significantly lower than in those sprayed twice

Table 2.—Treatment, average per cent infestation, and yields in sprayed and dusted cotton. Stanley Farm, Canadian, Oklahoma. 1949.

Treatment						Per Cent Boll Weevil Infestation		Per Cent Bollworm Infestation in Bolls	Aphids per Sq. In. Leaf Surface	Avg. Lbs. Seed Cotton
	Pounds per Acre per Application				Dates Applied					
Formulation	Calcium Arsenate	γ-BHC	DDT	Toxaphene		Squares	Bolls			Per Acre
Calcium arsenate 1% γ-BHC 5% DDT dust	9.4	0.12	0.58	—	7/16, 28; 8/4, 11	34.5	30.8	10.8	5.8	1131
Calcium arsenate 1% γ-BHC dust	10.5	0.12	—	—	7/16, 28; 8/4, 11	35.1	28.8	21.3	7.6	946
DDT-Toxaphene spray	—	—	0.75	1.5	7/16, 23; 8/1, 10	29.5	20.5	4.5	1.7	1212
Checks	—	—	—	—	—	64.6	71.3	18.3	2.4	659

during the squaring period at weekly intervals when both treatments were followed by two more sprays during the flowering period. The spray applied July 28 did not appreciably increase the yield and it is probable that likewise the dusts applied July 28 were ineffective in this respect. This was primarily because the cotton was suffering from drouth then.

Test Number 2.—This field was planted May 15 to Improved Rowden. Treatments were replicated twice and were started when the cotton was beginning to bloom. The plots consisted of from 0.73 to 1.1 acres and were from 12 to 18 rows wide. The plants never suffered from drouth. Because of the later date of planting and rank growth, bollworms as well as boll weevils caused severe injury. The average boll weevil infestation was 50 per cent when the test was started. A heavy cotton aphid infestation developed in the plots dusted with the calcium arsenate formulations.

All treatments produced a good increase in yield over the checks. The heavy aphid infestation did not reduce yields. The amount of gamma isomer in the calcium arsenate was not sufficient to control aphids. The toxaphene-DDT spray did not cause an increase in aphid infestation but neither did it control these pests. The calcium arsenate dust in the amounts used failed to control bollworms. However when 5 per cent DDT was added, good bollworm control was obtained. The toxaphene-DDT spray controlled both bollworms and boll weevils. Infestation and yield records showed that the dust formulation containing the DDT and the spray gave the greatest returns in increased yields because of better bollworm control. Plots dusted with the calcium arsenate-benzene hexachloride mixture, however, outyielded the checks. Increasing the pressure from 60 to 80 pounds resulted in an increase in the number of gallons of spray applied per acre.

Test Number 3.—This field was planted April 28 to a variety known as Coker 100. It was dusted June 23 with the 3-5-40 mixture at 10 pounds per acre. It was then sprayed weekly starting July 5 with the toxaphene-DDT emulsion using 2 nozzles per row until plant growth indicated better coverage could be obtained by using 3 nozzles per row. There were five spray applications averaging 1.5 pounds of toxaphene per acre per application. No infestation data were taken and no checks were left. However, this field was only about 250 yards distant from the field where test No. 1 was made, so the boll weevil infestation must have been approximately the same and as heavy. An average of 735 pounds of lint per acre was picked from this field indicating excellent boll weevil control. As the field was planted early and suffered from drouth, there was little chance for bollworm damage.

Test Number 4.—This was one of the earliest fields in this vicinity. Early boll weevil counts showed that this species was unusually abundant and would cause severe losses unless checked. The first square count made June 15 showed an average of 46 per cent of the squares to be infested by overwintered boll weevils. This field was sprayed June 15 and June 22 by airplane using the toxaphene-DDT emulsion at the rate of 1.75 pounds of toxaphene and 5 gallons of spray per acre. These sprays reduced the infestation to 11 per cent. Later dust applications were made and no yields were obtained. However, it proved that spraying by plane has good possibilities.

CONCLUSIONS.—Spraying cotton by plane or with a low-gallonage sprayer operated at from 60 to 80 psi, with an emulsion containing toxaphene and DDT gave good control of boll weevils and bollworms. The average amount of toxaphene applied varied from 1.6 to 1.8 pounds per acre per application. Comparative infestation counts and yields showed that control was as good as was obtained with several dust formulations recommended for boll weevil control.

Dr. Ralph H. Davidson, Department of Entomology, Ohio State University, has again accepted an invitation to teach Economic Entomology at the coming Summer School session of the University of Wisconsin.

Organic Insecticides for Control of Green June Beetle Larvae

C. B. Dominick, *Field Laboratory, Va. Agr. Expt. Station, Chatham*

During the past several years, green June beetle larvae, *Cotinis nitida* (L.) have been of increasing importance as a tobacco plantbed pest in Virginia. Green June beetle larvae injure tobacco plants in the plant bed by their burrowing and tunneling habits rather than by feeding on the plants. The larvae become active in the spring about the time the small seedlings are in the two to three leaf stage and in their search for decaying vegetable matter, the larvae uproot and kill tobacco plants.

Poison baits have been most commonly used by tobacco growers for the control of this insect in tobacco plant beds. The results obtained with these baits have not been completely satisfactory and there has existed a need for a more effective remedy that would give rapid results. Tests in the use of parathion and other organic insecticides for the control of green June beetle larvae have been in progress for the past three seasons. This is a preliminary report on experiments conducted during 1948 and 1949 for the control of the insect in tobacco plant beds.

Insecticides[1] Used and Experimental Procedure.—The following insecticides were used in the dust form: parathion, lindane, aldrin, dieldrin, heptachlor, chlordane and toxaphene. In addition the following insecticides were used as sprays: parathion, 25 per cent wettable powder; aldrin, 25 per cent wettable powder and dieldrin, 15 per cent wettable powder. The various dust and spray formulations and the rate per 100 square-yards at which they were applied are listed in the tables.

The treatments were replicated four times in randomized blocks of specially constructed plant beds; each plot consisting of an area of 1 square yard. The plant beds were constructed of 8-inch boards placed in the soil to a depth of 6 inches which largely discouraged larval migration. The plots were located in naturally infested areas; however, generally 10 to 50 larvae were added 2 to 3 weeks in advance of the treatments to obtain a more uniform population. At the time of treatment the larvae ranged from two-thirds to fully mature.

In the fall treatments the diluted dusts were applied by hand at the various rates of application to plant bed soil previously prepared for the chemical weed control treatment. The dusts were mixed with a small amount of moist soil to prevent drift and to provide a more uniform distribution. Following the application, the upper 2 inches of soil was cultivated and leveled to insure a thorough mixing of the toxicant. Treated and untreated plots were covered with cheesecloth covers to prevent predators from interrupting the experiments. Dead larvae were collected from the surface at intervals of 2 days and after 14 days the plots were excavated to a depth of 10 inches, and the soil was examined to recover dead and living larvae.

In experiments in which the insecticidal dusts were mixed with fertilizer and applied with the regular fertilizer application the toxicants in combination with the fertilizer were applied by hand to the surface of the soil, mixed with the upper 2 inches with a hoe, and seeded to tobacco on the following day. The plots were excavated 6 weeks after the seed had germinated and the results determined.

The treatments which were applied to the soil surface after seed germination had occurred were handled in a similar manner as the fall treatments; however, the toxicants were not mechanically mixed with the soil. The sprays were applied with hand equipment at the rate of 12.5 gallons per 100 square yards of plant bed area. Abbott's (1925) formula was used in computing the per cent control.

Soil Treatment During the Fall.—In preliminary experiments conducted during the fall of 1947, 1 per cent parathion dust when applied to tobacco plant bed soil at the rate of 4 pounds per 100 square yards resulted in rather rapid control. In one test consisting of 4 replicates

[1] The following companies contributed materials used in these experiments: American Cyanamid Co., New York, N. Y.; Julius Hyman and Co., Denver Colo.; California Spray-Chemical Corp., Elizabeth, N. J.; Hercules Powder Co., Wilmington, Del.; and Velsicol Corp., Chicago, Ill.

98 per cent control was obtained and in a second experiment, in which the toxicant was applied on a later date, 95 per cent of the larvae were killed. Accordingly more extensive experiments were planned for the 1948 season.

In the first experiment of the 1948 tests, parathion and lindane were used on October 4 at the rates indicated in table 1. In one series consisting of 4 replicates the materials were used alone while in the second the insecticides were applied at the time of the standard weed control treatment,[1] 150 pounds per 100 square yards. The insecticides were worked into the soil at the time of the second application of herbicide.

Table 1.—Control of green June beetle larvae in tobacco plant bed soil with parathion and lindane.

Treatment per 100 Square Yards	Recovered Larvae	Per Cent Control
Parathion 2 lbs., 1% dust	139	94.5
Parathion 3 lbs., 1% dust	126	95.7
Parathion 4 lbs., 1% dust	129	95.8
Lindane 2 lbs., 1.5% dust	146	71.8
Parathion 2 lbs., 1% dust plus *Aero Cyanamid*	135	93.7
Parathion 3 lbs., 1% dust plus *Aero Cyanamid*	127	94.9
Parathion 4 lbs., 1% dust plus *Aero Cyanamid*	125	95.7
Lindane 2 lbs., 1.5% dust plus *Aero Cyanamid*	133	88.7
Untreated	35	—

[1] Mortality 5.7 per cent.

The data are given in table 1. The results of this experiment indicate that parathion was highly effective in controlling green June beetle larvae and was equally effective at rates of 2 to 4 pounds of 1 per cent dust per 100 square yards. The data further indicate that under the conditions of the experiment, the toxicity of parathion was apparently not reduced when the insecticide was applied with the weed control treatment. In the tests lindane was less effective than parathion. When lindane was applied with the herbicide a greater per cent kill was obtained than when applied alone. One and three-fourths inches of rainfall occurred the first 24 hours after the treatment and a total of 2.75 inches was recorded during the 14-day period. The soil temperature ranged from 50° to 68° F.

In the second experiment, which was begun on October 8, 1948, parathion, lindane, toxaphene, and chlordane were used at rates and concentrations shown in table 2. The procedure was essentially the same as that used in experiment 1.

The data as given in table 2, indicate that parathion compared in toxicity favorably with the preceding experiment and was equally as effective at the 2 and 4 pound rates. Lindane, toxaphene, and chlordane at the rates used were less effective than parathion.

Table 2.—Control of green June beetle larvae in plant bed soil with parathion, lindane, toxaphene, and chlordane.

Treatment per 100 Square Yards	Recovered Larvae	Per Cent Control
Parathion 2 lbs., 1% dust	95	92.0
Parathion 4 lbs., 1% dust	90	93.8
Lindane 1 lb., 1.5% dust	90	73.2
Toxaphene 2 lbs., 5% dust	96	69.0
Chlordane 2 lbs., 5% dust	96	64.7
Untreated[1]	35	

[1] Mortality 8.6 per cent.

SOIL TREATMENTS FALL 1949.—In the 1949 experiments, in addition to parathion and lindane, aldrin, dieldrin, chlordane, and heptachlor were tested. Each insecticide was applied on September 20 to the soil as a 1 per cent dust at rates indicated in table 3.

Table 3.—Comparative effectiveness of several organic insecticides applied in the dust form for the control of green June beetle larvae in plant bed soil.

Treatment per 100 Square Yards	Soil Surface Activity	Recovered Larvae	Per Cent Control
Parathion 1% dust, 1 lb.	Moderate	123	89.7
Parathion 1% dust, 2 lbs.	Light	116	91.9
Parathion 1% dust, 4 lbs.	Light	172	93.6
Lindane 2 lbs.	Light	119	82.4
Aldrin, 4 lbs.	Heavy	123	70.5
Dieldrin, 4 lbs.	Heavy	118	68.5
Heptachlor 4 lbs.	Heavy	94	60.0
Chlordane 4 lbs.	Heavy	107	43.2
Parathion dust 2 lbs., plus Herbicide	Light	95	61.0
Dieldrin 2 lbs., plus Herbicide	Light	98	60.0
Aldrin 2 lbs., plus Herbicide	Light	101	53.1
Heptachlor 2 lbs., plus Herbicide	Light	103	52.8
Untreated[1]	Heavy	127	—

[1] Mortality 3.2 per cent.

The results in table 3 indicate that parathion was the most effective insecticide used and that there was little difference in the per cent control obtained

[1] *Aero Cyanamid.*

at rates of 1, 3, and 4 pounds of 1 per cent dust per 100 square yards. Lindane was next in order of effectiveness. Aldrin and dieldrin appeared to be about equal to each other in toxicity to the green June beetle larvae. Chlordane and heptachlor were the least effective of the insecticides tested. In the tests, the effectiveness of parathion, aldrin, dieldrin and heptachlor was greatly reduced at the rate of 2 pounds of 1 per cent dust when applied at the time of the weed control treatment. The results with parathion did not compare favorably with data obtained in 1948. In 1948, parathion dust applied at the time of the weed control treatment gave 93.7 per cent control of green June beetle larvae and in 1949 this treatment gave only 61 per cent control. The 1948 data, therefore, should be interpreted with caution as further work is needed to substantiate these results. Nine-tenths of an inch of rainfall occurred during the course of the experiment and the soil temperature ranged from as low as 48° to as high as 69° F.

PARATHION, ALDRIN AND DIELDRIN APPLIED TO SOIL WITH FERTILIZER APPLICATION.—An experiment was undertaken in 1949 to determine whether parathion, aldrin and dieldrin could be satisfactorily mixed with fertilizer and applied just prior to seeding and obtain green June beetle larvae control during the spring. The toxicants in combination with the fertilizer were applied to naturally infested plant bed soil on February 24. The plots were seeded to tobacco on the following day. Dead larvae were collected on the surface at intervals and all plots were excavated on April 25. Surface activity was light in all treated plots, however, the number of plants in the check plots was reduced approximately 80 per cent.

The results presented in table 4 indicate that parathion, when applied to the soil of tobacco plant beds with the fertilizer application, is effective in controlling green June beetle larvae. All larvae which came to, or near, the surface were apparently killed by the treatment. Aldrin and dieldrin were less effective in actual control of larvae; however, little surface activity occurred in plots treated with these insecticides. There was apparently no effect on seed germination or plant injury from the use of the insecticides.

Table 4.—Control of green June beetle larvae in tobacco plant beds with parathion, aldrin and dieldrin, applied with the fertilizer application.

TREATMENT PER 100 SQUARE YARDS	LARVAE RECOVERED	PER CENT CONTROL
Parathion 4 lbs., 1% dust	53	92.3
Aldrin, 4 lbs., 1% dust	53	70.8
Dieldrin, 4 lbs., 1% dust	48	67.8
Untreated[1]	63	—

[1] Mortality 3.1 per cent.

SURFACE APPLICATION OF SPRAYS AND DUSTS.—Inasmuch as many tobacco growers are not aware of the presence of green June beetle larvae in previously prepared plant beds, the following experiment was designed to determine if sprays and dusts could be applied in the plant bed after seed germination had occurred and obtain adequate larval control. The plots, located in soil infested with green June beetle larvae, were treated on April 15 at which time the tobacco plants were in the three to four leaf stage. Larval activity was quite noticeable in the plots at the time of the treatment. The sprays were applied at the rate of 12.5 gallons per 100 square yards; the insecticides being used at concentrations indicated in table 5. Larvae were collected from the surface at intervals and all plots were excavated 14 days later.

Table 5.—Control of green June beetle larvae in tobacco plant beds with organic insecticides applied to the soil surface.

TREATMENT	RECOVERED LARVAE	PER CENT CONTROL
Parathion 1 lb. 25% wettable powder 100 gal. water	93	90.8
Aldrin, 1 lb. 25% wettable powder 100 gal. water	74	55.4
Dieldrin, 1 lb. 15% wettable powder 100 gal. water	86	36.1
Parathion 4 lbs. 1% dust	91	95.3
Parathion 2 lbs. 1% dust	91	90.6
Dieldrin, 4 lbs. 1% dust	96	59.0
Untreated[1]	84	—

[1] Mortality 6.0 per cent.

The data are presented in table 5. In the tests parathion proved to be the most effective insecticide when used both as a spray and dust. Aldrin and dieldrin were not effective at the rates used although there was little surface activity after the treatments were made.

PHYTOTOXICITY.—On February 21, 1949, parathion, aldrin, dieldrin and lindane 1 per cent dusts were applied to small replicated plant beds at the rates of 4 and 8 pounds per 100 square yards 4 days after the fertilizer application. In addition a 5 per cent chlordane and toxaphene dust were also used. The beds were seeded to tobacco on February 24. There was apparently no effect on the germination in treated plots when compared with the checks. The plants were observed during all stages of growth and no differences were detected.

SUMMARY.—Experiments conducted during 1948 and 1949, indicate that parathion, when applied to the upper 2 inches of soil at rates ranging from 1 to 4 pounds of 1 per cent dust per 100 square yards, was highly effective in controlling green June beetle larvae. Inconsistent results were obtained when parathion was applied at the same time of the standard weed control treatment, consisting of 150 pounds herbicide[1] per 100 square yards. Parathion applied to the soil with the fertilizer application prior to seeding also gave effective larval control. Aldrin and dieldrin were less effective in actual larval control; however, little surface activity occurred in plots treated with these insecticides. Parathion proved to be effective as a surface spray, 1 pound 25 per cent wettable powder in 100 gallons of water, when applied at the rate of 12.5 gallons per 100 square yards, and as a dust, 2 to 4 pounds 1 per cent, applied in the spring after surface activity had occurred. Lindane, aldrin, dieldrin, toxaphene, heptachlor, and chlordane were all less effective than parathion.

No plant injury was noted from the use of these insecticides as soil treatments before seeding. Parathion, aldrin and dieldrin were used as surface sprays and dusts without injury to the plants.

[1] *Aero Cynamid.*

LITERATURE CITED

Abbott, W. S. 1925. A method of computing the effectiveness of an insecticide. JOUR. ECON. ENT. 18(2) 265–7.

Residues on Citrus Trees in Florida: Changes in Purple Scale and Rust Mite Populations Following the Use of Various Spray Materials

J. T. GRIFFITHS and FRAN. E. FISHER, *Florida Citrus Experiment Station, Lake Alfred*

Spray residues have long been associated with increases of both insects and mites on citrus in Florida. It is not feasible to refer to all of the work which has been published upon the residue problem, but certain representative papers should be mentioned as they apply to the present discussion. In 1938, Thompson (1939) discussed in some detail the effects of various amounts of copper and zinc residues. He concluded that sprays containing copper and zinc caused increases in purple scale populations in direct proportion to the amount of material used per 100 gallons of spray. In the same year, Spencer (1939) reported similar work on both purple and Florida red scales. He concluded that the presence or absence of copper was unimportant and that the total amount of residue was the primary factor to be considered. His work was analyzed statistically, and he stated that there was no significant difference between the two treatments which contained 12 pounds of spray material per 100 gallons. One of these was 6-6-100 bordeaux and the other had aluminum sulfate substituted for the copper. In spite of the fact that he concluded that there was no difference between these two materials, he reported, in the case of purple scales, twice as many actual insects on the fruit from trees sprayed with copper. Similarly, the percentage of fruit infested with red scales increased from approximately 25 to 71 percent when copper sulfate was substituted for the aluminum sulfate and the number of actual scales increased from 422 to 2467 for the sample examined. In this latter instance, these differences were greater than that needed for significance between the unsprayed control and the

aluminum sulfate-lime spray. When these data are considered, it would seem difficult to conclude that copper was unimportant as a factor in causing increase in scale build-up. However, he does definitely show that 12 pounds of spray material per 100 gallons caused increased scale as compared with one pound or none.

In 1943, Holloway & Young (1943) reported work on fungicidal sprays and their effects on purple scales in Florida. They concluded, as did Spencer (1939), that copper was of no consequence, and that the amount of residue was the primary cause. Their conclusions were drawn on the basis of single counts in each of two years. These counts were made in August 1938 and again in August 1939. In each of these three papers, indications were that increasing the amounts of spray materials per unit amount of spray increased the build-up of scale insect populations. Griffiths & Fisher (1949) reported in 1949 that the physical presence of either pyrophyllite, sulfur, copper, or zinc containing compounds was instrumental in increasing the number of scales on citrus trees. They showed further that, where the same amount of material was applied per 100 gallons of spray, chemical differences determined the extent and duration of the abnormally high populations. From the standpoint of prolonged high scale populations, sprays containing copper or zinc or both presented greater hazards to the citrus grower than did those containing sulfur or pyrophyllite.

In summary, these papers demonstrate that copper and zinc have often been associated with scale increases and that such increases may be directly correlated with the amount of material used per 100 gallons of spray. In Florida, copper is used on citrus for the control of two diseases, melanose and scab, and also as a nutritional element; it is most often applied within 1 to 3 weeks after the bloom has set. Zinc is used only as a nutritional element and is applied during January or February or in the post-bloom spray. Although these two materials are integral parts of the citrus spraying program, it is hoped that, by a better understanding of the action of these residues on citrus foliage it may be possible to make some alterations in the present spray recommendations in order that the deleterious effects may be minimized. The results reported here are part of an experimental program which has been established to determine the interaction between residues on foliage and changes in the insect and mite populations. In this phase of the program, differences in the amounts of spray residues applied were studied as well as differences between three zinc mixtures, a copper compound, and two inert[1] materials, lime and pyrophyllite. This study includes the effects of these spray treatments on purple scale *Lepidosaphes beckii* (Newm.) populations and the citrus rust mite *Phyllocoptruta oleivora* (Ashm.), as well as the effects upon three fungi which have been found to be associated with scale and mite mortality. One fungus, *Myophagus* sp. Thaxter, has been shown to be parasitic on purple scale (Fisher *et al.* 1949) and to be an important factor in its natural control. The species, *Hirsutella Besseyi* Fisher and *H. Thompsonii* Fisher, have been found associated with the mortality of young purple scales (Fisher *et al.* 1949) and rust mites (Fisher *et al.* 1949) respectively. Whether they are actively parasitic has not been determined.

METHODS.—The present experiment was performed during the 1949 growing season. Sprays were first applied in the spring (March and April) with a second spray application the first of June. A series of seven different treatments included: unsprayed control, zinc sulfate (36 per cent Zn), zinc sulfate+lime, pyrophyllite, lime, a basic copper (34 per cent copper as $(Cu(OH)_2)_x CuSO_4$), and a zinc compound (55 per cent Zn) known commercially as zinc carbonate. (Other zinc compounds were probably present, but these could not be ascertained.) All treatments were applied at two concentrations: 4 and 8 pounds per 100 gallons of spray. Zinc sulfate and lime were used at a 3 to 1 ratio. The experiment was designed for several purposes: to show whether the increases caused by zinc sulfate plus lime were due primarily to the zinc sulfate or to the lime; to compare alkaline lime with a more acid material, pyrophyllite; to compare zinc carbonate as a neutral zinc with zinc sulfate plus lime; to compare copper with zinc; and to study differences resulting from doubling the concentrations. These treatments

[1] The term inert, as used here, refers to materials which have no known insecticidal or fungicidal action.

were applied to two different orange blocks: one contained Pineapple oranges and one Valencia oranges. Two trees were included on each residue level. Thus, there were two Pineapple trees and two Valencia trees sprayed with each individual treatment. This made a total of eight trees with any one chemical treatment and a total of 24 trees at each residue level. Four unsprayed controls were included in each of the two blocks. Purple scale counts made at monthly intervals (June through December) were recorded as the per cent of quarter leaves infested with live purple scales. These counts were based on methods previously described by Griffiths & Thompson (1949). Counts to determine the per cent of infested leaves which had scales parasitized by *Myiophagus* sp. Thaxter, (chytridiosis), were made at approximately monthly intervals throughout the period from June through November in both blocks. In conjunction with the chytridiosis examinations, counts were made of the scale-infested leaves having young scales infected with *Hirsutella Besseyi* Fisher. These entomogenous fungus counts were based on 20 randomly selected scale-infested leaves per tree. This method of counting has shown itself to be more practical than that used previously by Griffiths & Fisher (1949).

Counts of citrus rust mites were also made throughout the summer period in order to determine the effects of the various treatments on the populations.

RESULTS.—*Effects of Scale Insect Populations.*—Figures 1 and 2 show the changes in purple scale populations for the two blocks involved. The results obtained on the two levels of residue are lumped together so that each point on the graphs actually represents an average of four trees. The data are presented as the percentage change from the original population. Initial populations were similar within a given block, and this method was used rather than plotting actual per cent infestation. It will be noted that, in general, the trends in the two graphs are quite similar, and that the unsprayed control, in both cases, maintained a very low population. The trees sprayed with zinc carbonate and with zinc sulfate plus lime were the two most heavily infested plots in both series. Where no lime was used to neutralize the zinc sulfate, scale populations exhibited erratic changes. Zinc sulfate is soluble in aqueous solution, and the peculiar behavior of scale infestations following its use is probably associated with this fact. In both blocks one of the spray applications was followed within three or four hours by at least an inch of rain, and the June sprays were applied at the beginning of the rainy season. Casual examination of the leaves showed that very little zinc residue actually remained on the foliage. This could be attributed to the rains following the spray, and also to the fact that zinc sulfate remained on the

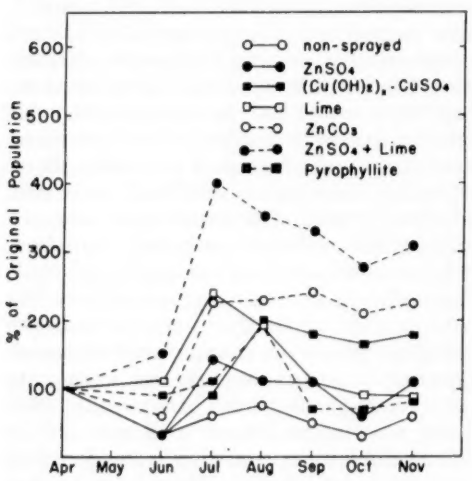

FIG. 1.—Changes in purple scale populations following the use of residue sprays in a Pineapple orange block.

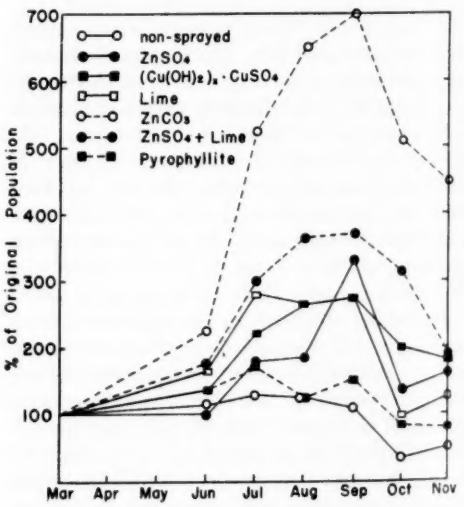

FIG. 2.—Changes in purple scale populations following the use of residue sprays in a Valencia orange block.

foliage only where drops of spray were actually held on the oily citrus leaves. These trees did not show the rapid initial scale increases experienced with other zinc treatments, but in the Pineapple orange block an increase occurred in September. It is entirely possible that this increase was due to sampling error, but, in any case, the trees sprayed with zinc sulfate, which was not neutralized with lime, assumed an intermediate position among the various treatments.

The scale infestations on the trees sprayed with copper increased more slowly than many of the others, but in both sets of experiments the copper-sprayed trees had the third highest scale infestations at the end of the season. Similar tendencies were observed in 1948. Previously, it was noted that Holloway & Young had concluded that the amount of residue rather than the presence of copper was the factor responsible for the increases in purple scale populations on citrus trees in Florida. Their counts were made in August of each year. It should be noted that if August counts were taken as a criterion in both of the two series of plots reported here, it would be seen that trees sprayed with either copper or lime had identical scale populations at that time. Prior to that date the highest populations had been found where lime was used, but following that date the highest populations were found on copper-sprayed trees. From the data presented in Figures 1 and 2, it is obvious that the effects of copper and lime are different and that their chemical nature must be a major factor in the influence which they have upon purple scale population changes. Scale damage to trees more frequently occurs in the fall than in early summer, and, from this standpoint, copper would theoretically present a greater hazard than lime alone.

Initially the trees sprayed with lime had rapid increases of purple scales. This infestation reached a maximum in July, and then either stabilized or decreased from July through September. In October, fewer leaves were infested than at the beginning of the experiment. In both series, scale infestations on the trees sprayed with pyrophyllite did not attain levels as high as on those sprayed with lime. In general, the scale populations on the pyrophyllite sprayed trees followed a pattern intermediate between that of lime and the unsprayed controls.

Although this experiment was designed primarily to observe differences between four and eight pounds of spray material per 100 gallons of water, no differences were found. Table 1 shows that there was no real difference between the two residue levels in either experimental series, although slightly higher infestations were present in the Pineapple oranges at the end of the season. Similar populations were present at the beginning of the experiment, and this similarity continued throughout the season. Differences are not evident on any individual treatments. On the basis of work by previous investigators plots with 8 pounds of spray material would have been expected to have higher scale populations than plots with 4 pounds of spray residue; however, these differential scale populations did not occur. At this time, no adequate explanations can be offered to account for the evidence herein presented as it is opposed to the generally accepted theory that scale increases are usually in direct proportion to the amounts of residue.

Table 1.—Comparison of the percentage of leaves infested with purple scales following the use of sprays with either 4 or 8 lbs. of spray material per 100 gallons.

	Pineapple Oranges			Valencia Oranges	
Dated Counted	4 lbs.	8 lbs.	Date Counted	4 lbs.	8 lbs.
Mar. 16	18	19	Apr. 20	14	14
June 7	29	25	June 9	11	10
July 12	48	46	July 12	26	26
Aug. 17	44	56	Aug. 17	29	28
Sept. 15	52	58	Sept. 15	24	22
Oct. 10	28	36	Oct. 11	15	24
Nov. 8	28	30	Nov. 10	20	24
Nov. 29	17	20	Nov. 29	12	12

Table 2.—Comparison of rust mite populations following the use of different residue sprays.

Treatment	Pineapple			Valencia	
	July 12 Per Cent Fruit Infested	Aug. 16 Per Cent Leaves Infested	Aug. 31 Per Cent Leaves Infested	Aug. 16 Per Cent Leaves Infested	Sept. 1[1] Per Cent Leaves Infested
$ZnSO_4$+lime	90	53	0	85	10
$ZnSO_4$	83	62	7	50	6
Lime	95	37	3	51	4
Pyrox	95	32	0	44	1
$ZnCO_3$	98	89	0	65	5
$CuSO_4 \cdot Cu(OH)_2$	90	84	12	70	8
Unsprayed	95	19	0	34	1

[1] Hurricane on August 26.

Effects on Chytridiosis.—Figures 3 and 4 show the changes in the amount of chytridiosis throughout the experimental period. Scale populations were generally lower in the Valencia oranges than in the Pineapple oranges, and this consequently resulted in less incidence of chytridiosis in the Valencia oranges. In both blocks the maximum amount of chytridiosis occurred about August 1. The highest incidence of chytridiosis was on the lime, the pyrophyllite, and the unsprayed control plots. The zinc sulfate alone had an intermediate position and the three lowest ranking treatments were the zinc carbonate, zinc sulfate plus lime, and copper. Generally the plots showed decreases in late August and early September, and there were some increases in October, with succeeding decreases again in November. A comparison of Figures 3 and 4 with Figures 1 and 2 shows that high chytrid populations are generally correlated with declining scale populations, but this was not always the case. Although chytridiosis is a major disease of purple scales, it must be considered that other factors besides chytridiosis act in the natural control of these insects.

Effects on Hirsutella Besseyi Fisher.—Figure 5 illustrates the changes in the percentage of young scales attacked by *Hirsutella* in the Pineapple orange block. Similar graphs for such counts in the Valencia block are not included because, even though percentages followed the same general patterns, the number of scales attacked with *Hirsutella* in this block at no time attained numbers which could be considered to be of any material consequence. Fisher has suggested that *Hirsutella Besseyi* may be either a parasite of young scales, or that it may

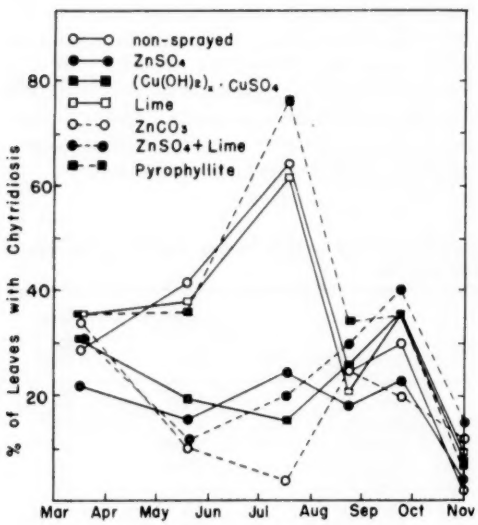

FIG. 3.—Per cent of scale-infested leaves with chytriodiosis on Pineapple oranges infested.

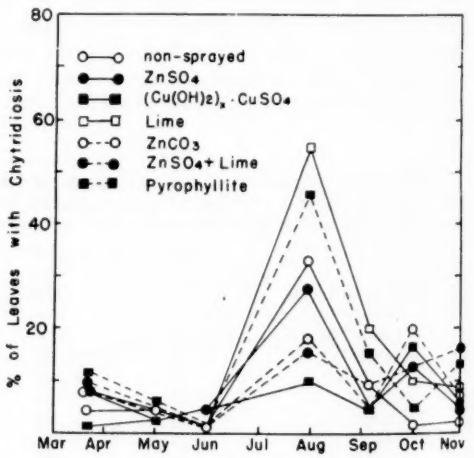

FIG. 4.—Per cent of scale-infested leaves infested with chytridiosis on Valencia oranges.

be a specific indicator of some disease which has killed the scale and then the fungus appears as a saprophyte. Although evidence to clarify this situation is needed, when high mortalities of young scales occur, it is consistently found that their bodies are filled with this fungus organism. The difference between the two blocks cannot be explained fully, but may be attributed to the differences in the scale populations. The Valencias consistently had lower scale populations, and, as a result, fewer fungi than did the Pineapples. It should be noted that the effects of the spray treatments on *Hirsutella* are almost identical with the effects on chytridiosis, and the plots shown in figure 5 have similar patterns as those in the two preceding figures.

Effect on Rust Mites.—Table 2 shows rust mite counts made during July and August in the two blocks. Only these counts are shown because only on these dates were differential numbers found. Rust mite populations may increase very rapidly, and on occasion decrease in the same manner. As a result, it is often difficult to show actual differences between various treatments. In both blocks there were uniformly heavy rust mite infestations on all trees by July. In counts in the Pineapple orange block there were no differences between any of the various treatments. On August 16, however, counts in both blocks seemed to show trends which are considered to be of some importance. In each block the lowest infestation was on the unsprayed control, but the pyrophyllite and lime sprayed plots were also low. Generally, the zinc and copper sprayed trees were high. No definite conclusions can be drawn from these data, but the indications are similar to those noted previously by the authors (3). The effect of copper was originally reported by Winston *et al.* (1923). The counts made on August 16 were at a time when rust mite populations were actually decreasing. These decreases may have been due to the presence of the fungus, *Hirsutella Thompsonii* Fisher. The dead rust mites were consistently found containing endoparasitic hyphal bodies, and later a fungus, *Hirsutella Thompsonii* was found on the dead rust mites. (Fisher 1949.) Whether or not this organism originates from the endoparasitic hyphal bodies found in the living but abnormal mites has not been proved, but as in the case of *Hirsutella* and purple scale nymphs, it is associated with their mortality. From the data presented, it appears that previous sprays containing copper and zinc affect the rust mite populations in that reductions in the mite populations are retarded. Additional counts for both series of plots are shown for August 31 and September 1. These counts are very low as compared with those made 15 days earlier. A hurricane occurred on August 26–27, and the heavy rains and wind coupled with already decreasing mite populations resulted in very low infestations on those dates.

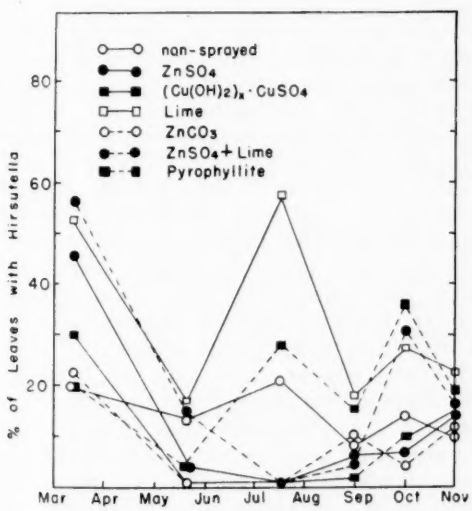

FIG. 5.—Per cent of scale-infested leaves infested with *Hirsutella* on Pineapple oranges.

DISCUSSION.—An interpretation of all of the data presented here is impossible at the present time. However, certain trends and indications are evident. Sprays containing copper and zinc caused greater increases and more prolonged periods of high scale infestation than did pyrophyllite or lime. On the basis of this work the authors believe that the primary effect is exerted by the presence of the zinc or copper cation, irrespective of the form of the salt. Lime certainly caused rapid increases. This is especially true when it is compared with another inert material, pyrophyllite. Whether the difference in pH is a factor cannot be determined at present. It should be pointed out that lime sticks more readily on citrus foliage, and that high levels of residue are main-

tained over a more prolonged periods than in the case of pyrophyllite. This may be one of the major factors in the difference between the two spray materials. However, such factors as pH and particle size should not be overlooked at this time. These data agree with those presented by the authors (1949) previously, in that residue-containing sprays were generally instrumental in creating higher scale infestations than were found on unsprayed controls. In general, the worst scale infestations followed zinc and copper-containing sprays.

Another factor was demonstrated in 1949, for which a tendency was found in the preceding year. In both series of plots in 1949, the copper-containing sprays resulted in less scale build-up and lower populations at the end of the year than did zinc sulfate plus lime or zinc carbonate. This tendency was also noted in 1948 when, in one case, the copper-containing sprays very definitely resulted in lower infestations than the zinc-containing sprays. More data are necessary before definite conclusions on this factor can be reached, but it appears to be necessary to consider the possibility that from a scale standpoint, zinc may actually be more detrimental than copper. This thought has been expressed by some citrus growers in the state, but they have formed this opinion from casual observations rather than from experimental evidence.

Zinc is used as a nutritional spray in Florida, and the amounts of zinc sprayed by growers may vary from one grove to another. Usually the zinc is applied at the rate of 3 pounds of zinc sulfate plus one pound of lime per 100 gallons of spray. The amount of spray that is applied per tree varies with each individual operation. Large trees may be sprayed with as little as 5 gallons or as much as 25 gallons. This results in wide differences in the amounts of zinc residues left on the trees. It also suggests the possibility that some growers are over-spraying with zinc, while others are probably underspraying. There may be the possibility that some change could be made in the amount of zinc to be used. At the same time, it will be noted from the results presented here that while higher infestations of scale followed zinc carbonate than zinc sulfate plus lime in one series of experiments lower infestations followed in the other. This was true even though the zinc carbonate sprays contained twice as much metallic zinc as did the zinc sulfate plus lime. Providing the nutritional value on a metallic basis is similar, the use of neutral zinc materials such as zinc carbonate with a high metallic zinc content can lead to a material reduction in the amount of residue remaining on the trees following a spray application. Recommendations along these lines cannot be made at the present time, but certainly they may be anticipated.

The results noted on chytridiosis and *Hirsutella* infection rates indicate that copper and zinc containing sprays are reducing the numbers of these fungi. In the case of chytridiosis, it is a proved fact that the reduction of the fungus causing this disease is detrimental to scale control, and it is possible that the same thing is true in the case of *Hirsutella*. A similar situation appears to exist in the rust mite populations as regards their relationship with the *Hirsutella* fungus.

SUMMARY AND CONCLUSIONS.—In 1949, in two orange blocks, trees receiving sprays containing zinc sulfate, zinc sulfate plus lime, lime, pyrophyllite, basic copper, and zinc carbonate were compared with nonsprayed ones. All materials were used at both 4 and 8 pounds of spray material per 100 gallons of spray. Two applications were made: one in the spring and a second one in the early part of June. The sprays containing zinc carbonate, zinc sulfate plus lime and basic copper resulted in higher and more prolonged periods of purple scale infestations than did the other treatments. The nonsprayed controls showed the smallest increase and the lowest scale population of all plots throughout the entire experimental period. Copper and zinc sprays resulted in fewer scales infected with the chytrid, *Myiophagus* sp., and with *Hirsutella Besseyi* than did the other treatments. On August 16, rust mite populations were found to have been affected by the various spray materials; the unsprayed controls had the lowest numbers of rust mites and the zinc and copper plots had the highest numbers of rust mites. From the data presented, it is concluded that sprays containing zinc and copper had more detrimental effects upon purple scale and rust mite populations than did sprays containing lime or pyrophyllite. Lime appeared to have more detrimental effects than did

pyrophyllite. All sprays resulted in higher scale and rust mite populations than were found on the unsprayed controls. No differences between 4 and 8 pounds of material per 100 gallons of spray were found.

LITERATURE CITED

Fisher, F. E., J. T. Griffiths and W. L. Thompson. 1949. An epizootic of *Phyllocoptruta oleivora* (Ashm.) on citrus in Florida. Phytopath. **39**: 510–2.

Fisher, F. E., W. L. Thompson and J. T. Griffiths. 1949. Progress Report on the fungus diseases attacking scale insects in Florida. Fla. Ent. **32**: 1–11.

Griffiths, J. T. and F. E. Fisher. 1949. Residues on citrus trees in Florida. I. Changes in insect populations following the use of different chemical materials used at the same amounts of residue per 100 gallons of spray. JOUR. ECON. ENT. **42**: 829–33.

Griffiths, J. T. and W. L. Thompson. 1949. Identification of Florida red and purple scales on citrus trees in Florida. Fla. Agr. Expt. Sta. Circ. **S-5**.

Holloway, J. K. and T. R. Young, Jr. 1943. The influence of fungicidal sprays on entomogenous fungi and purple scale in Florida. JOUR. ECON. ENT. **36**: 453–7.

Spencer, Herbert. 1939. Increases in citrus scale infestations from heavy residue and from copper spray mixtures. JOUR. ECON. ENT. **32**: 686–8.

Thompson, W. L. 1939. Cultural practices and their influence upon citrus pests. JOUR. ECON. ENT. **32**: 782–9.

Winston, J. R., J. J. Bowman, and W. W. Yothers. 1923. Bordeaux-oil emulsion. U.S.D.A. Bul. 1178.

Entomogenous Fungi Attacking Scale Insects and Rust Mites on Citrus in Florida[1]

FRAN. E. FISHER

For many years, a diversity of opinion has existed as to the efficiency of the red-headed fungi which attack various scale insects on Citrus in Florida. In 1946, a research project was begun with the objectives of: (a) determining the true status of the red-headed fungi; (b) making a study of the diseases of citrus insects with primary emphasis on scale insects; and (c) learning how these diseases could be used in conjunction with a spraying program. The purpose of this report is to point out the evidence which has been presented to sustain and to reject the theory that the red-headed fungi are true parasites, and to summarize the results of recent research on the diseases of citrus insects in Florida.

PURPLE AND FLORIDA RED SCALES.—*The Red-Headed Fungi.*—Since Rolfs' (1897) experiments with *Sphaerostilbe aurantiicola*[2] on San Jose scale, *Aspidiotus perniciosus* Comst., attacking peach and plum trees, three red-headed fungi have been credited by some investigators and growers with being parasitic on purple, *Lepidosaphes beckii* (Newm.), and Florida red, *Chrysomphalus aonidum* (L.), scale insects attacking Citrus. The fungi usually grouped under the general term, red-headed fungi are: *Sphaerostilbe aurantiicola* (Berk. & Br.) Petch, *S. flammea* Tul., and *Nectria diploa* Berk. & Curt. Although the latter is called the pink-headed fungus the three are not readily distinguished from each other except by specialists, and when present in large numbers, any one or a combination of all three may actually cause the tree to appear reddish in color.

The problem of which red-headed fungus is predominately present arose in 1946 when Mr. Erdman West[3] remarked that although *Sphaerostilbe aurantiicola* was regarded as being *the* red-headed fungus, the majority of the perfect stage specimens on twigs that he had identified during the past 25 years were *Sphaerostilbe flammea.* He and the writer have identified the red-headed fungus which is at this time the most common on leaves infested with both purple and Florida red scales as *Microcera Fujikuroi* Miy & Sa., the imperfect stage of *Nectria diploa.* Although *Microcera aurantiicola* Petch, *Sphaerostilbe aurantiicola,* is frequently found, the writer has not seen it occurring in such abundance as is true concerning

[1] Tampa, December, 1949, Annual Meeting.

[2] Rolfs used the name *Sphaerostilbe coccophila* Tul. Later T. Petch (1921) in a taxonomic study reported the correct name to be *Sphaerostilbe aurantiicola* (Berk. and Br.) Petch.

[3] Mycologist and Botanist, Florida Agricultural Experiment Station, Gainesville, Florida.

Microcera Fujikuroi (*Nectria diploa*).

During the course of the writer's investigations, it has been found that there is not only some uncertainty as to the accuracy of the identifications of the fungi which were used by the investigators following Rolfs, but also Petch (1921) has pointed out that it is not known whether Rolfs actually used *Sphaerostilbe aurantiicola* or *Nectria diploa*. Although no evidence was presented, Petch also reported that his examinations of herbarium specimens had shown that *Nectria diploa* and *Sphaerostilbe flammea* were parasitic on scale insects.

According to Watson & Berger (1937), *Nectria diploa* was especially effective against Florida red scales; whereas, *Sphaerostilbe aurantiicola* was parasitic on purple scales. Although they stated in their bulletin on citrus insects that they adopted the names of fungi as revised by Petch and as given by Fawcett (1936), they neglected to list *Sphaerostilbe flammea* and also confused the descriptions of the other red-headed fungi. The description given for *Nectria diploa* is that of the imperfect stage, *Microcera Fujikuroi*, whereas the description of *Sphaerostilbe aurantiicola* was that of the perfect stage. This has apparently caused some confusion due to the fact that the perfect stages rarely or only occasionally are seen. The imperfect stages are found in abundance and are strikingly similar. In fact, it is quite difficult, or almost impossible, to differentiate between these fungi during the process of making routine scale and fungus counts. Mr. W. L. Thompson (1938, 1939, 1949) has personally stated to the writer that he followed the identifications of Watson & Berger (1937). It is not known definitely, but it would seem that in many instances the fungi used by research workers were not identified by qualified taxonomists. As a result, it is evident that it is not only a question of the parasitism of the red-headed fungi, but also a question of which of the red-headed fungi were actually referred to in each of the numerous publications.

Webber (1897) reported that purple, Florida red, and long scales increased following bordeaux sprays. He attributed these increases to the fact that the entomogenous fungi were killed. O'Byrne (1916) noted increases in purple scale infestations following bordeaux applications, and Hayman (1934) reported increases in scales following applications of zinc sulfate. Rolfs & Fawcett (1908) discussed the efficacy of the red-headed fungus, *Sphaerostilbe aurantiicola*, in a bulletin on the fungus diseases of scale insects and whiteflies. Fawcett (1912) also found that bordeaux mixture caused an overwhelming increase of scale insects, and that the use of commercial lime-sulfur at first somewhat diminished the number of scale insects, but later caused a slight increase. He pointed out that the evident reason for the scale increases following bordeaux was that the spray killed the fungi which parasitized the insects. Hill *et al.* (1934) reported that a natural control of about 60 per cent of the purple scales in unsprayed groves could be expected, but when groves were sprayed with bordeaux only about 20 per cent control could be expected. Winston *et al.* (1923) reported that experiments in which plots were sprayed weekly from April until the end of July with bordeaux plus 0.5 per cent oil emulsion resulted in such high populations that it was necessary to spray them with 1 per cent oil emulsion on August 13. Following these workers, Watson (1937) & Berger (1910, 1921, 1932) were the leading supporters of the so-called friendly fungi.

Miller (1937) reported that a very small quantity of sulfur on citrus trees would occasionally result in severe scale populations. Thompson in summarizing a series of experiments, found that copper sprays reduced the number of entomogenous fungi and suggested that the reduction of these fungi might be responsible for some increase of scale. Spencer & Osborn (1938) noted that bordeaux sprays eliminated the entomogenous fungi and resulted in scale population increases. Later Thompson (1939) concluded that, under a spraying program including copper and zinc compounds, the red-headed fungi had little or no appreciable effect in controlling purple and Florida red scales.

Throughout the available literature on the efficacy of the red-headed fungi, none of these investigators has reported seeing one of these fungi actually growing on a living purple or Florida red scale insect, nor has any evidence been presented to demonstrate conclusively that these fungi

are of any importance in the natural control of citrus scale insects. Forbes (1899) after visiting Rolfs (1897) in Florida, returned to Illinois and conducted experiments with the red-headed fungus, *Sphaerostilbe aurantiicola*. In reporting the experiments he wrote, in part:

"The fact should be carefully noted that however generally the fungus was distributed, it was easy to find everywhere in the infected area scale insects still living and apparently not invaded by it, and even young scales crawling about in considerable number. It remains to be seen, consequently, how completely even thoroughly infected areas may be cleaned of the scale by this fungus, since it is possible that only those scales which were in some way comparatively deficient in vitality were actually destroyed by the parasite. Contrary to this supposition we have only the observations made in Florida, where, again, it is not impossible that other and inconspicuous causes have conspired with the *Sphaerostilbe* to reduce the number of the scale."

Even though the parasitism of these fungi on these insects never has been proved, a number of investigators have presented evidence to show that the red-headed fungi are not parasitic on purple and Florida red scales. Earle (1899) also reported that, in experiments on San Jose scale attacking apple trees in Alabama, *Sphaerostilbe* seemed to be entirely inefficient. An unpublished manuscript by Mr. W. L. Thompson presented evidence to show that the red-headed fungi were not parasites, but were only saprophytes living on the armors and dead bodies of the insects. He noted that large numbers of purple scales had been found with the red-headed fungi growing on the armors but not attacking the living bodies of the insect. Holloway & Young (1943) found similar results by comparing the effects of copper carbonate plus ammonia, copper sulfate plus lime, and aluminum sulfate plus lime. They concluded that the scarcity or abundance of *Sphaerostilbe aurantiicola* and *Nectria diploa* did not influence the total mortality of purple scales.

Fisher *et al.* (1949) reported that all attempts to inoculate red and purple scales with the red-headed fungi had failed, and that no evidence had been found that the red-headed fungi parasitized red or purple scale insects. However, they found red-headed fungi in large numbers on purple scales which had been killed by insecticidal sprays. It was noted that the red-headed fungi had been observed in many instances growing on the armors, but not attacking the living scale underneath the same armor.

Ziegler (1949) also found large numbers of red-headed fungi following insecticidal sprays. He concluded that the red-headed fungi were not operative as factors in the control of purple scale insects.

In summarizing the literature from 1897 to 1940, it is evident that very little controlled experimental work was actually performed during this period, and that insufficient data was presented either to reject or to sustain the hypothesis that the red-headed fungi are parasitic upon purple and Florida red scales. Since it is not known if the earlier investigators were accurate in differentiating between *Sphaerostilbe aurantiicola*, *Sphaerostilbe flammea* and *Nectria diploa*, it would seem that much of the evidence which has been presented can not be properly evaluated. Recent research workers have found no evidence to demonstrate that the red-headed fungi are parasitic on scale insects. Without evidence of the parasitic nature of any one or all of the red-headed fungi it should not be assumed that they act as parasites.

CHYTRIDIOSIS.—A disease of scale insects caused by the endoparasitic chytrid, *Myiophagus* sp. Thaxter, has been termed chytridiosis by Karling (1948). This fungus was first found parasitizing purple scale insects on citrus by Thompson in 1934 at Babson Park, but was not identified until 1946 by Fisher *et al.* (1949).

The following hosts have been recorded in Florida: purple scale, *Lepidosaphes beckii* Newm., Florida red scale, *Chrysomphalus aonidum* L., chaff scale, *Parlatoria pergandii* Comst., and *L. gloverii* Pack. Although *Myiophagus* sp. has a wide host range, in Florida it appears to be of economic importance only on purple scale. It has been found frequently on Florida red scales, but has not been found to occur in sufficiently large numbers to cause epizootics.

Purple scales infected by *Myiophagus* are easily recognized in the early stages of the disease when the insects are still alive. The first indication of the disease is a

slight color change of the body, which is normally white, to a pale coral-pink tint. Later, as the disease progresses and the insect dies, the zoosporangia develop internally giving the scale a bright orange color. After the insect is dead, the zoosporangia mature, and the insect's body becomes a powdery mass of golden-yellow zoosporangia. If resting zoosporangia are present, all or part of the body may be brick-red in color.

When sufficient moisture is present to wet the leaves thoroughly, the zoosporangia in the dead scales germinate producing swimming zoospores which swim in the film of water until they come into contact with a healthy scale, and then produce germ tubes which penetrate the integument of the insect. In this manner, healthy scales become infected and all subsequent growth of the parasite is internal. Zoosporangia are again produced, at the expense of the insect's life, and the release of zoospores completes the life cycle of the fungus.

The life cycle of *Myiophagus* sp. makes it readily apparent that this fungus is a true parasite and that not only is it directly dependent upon the density and distribution of the scale population, but also upon moisture without which germination of the zoosporangia and infection of the scales is impossible.

Hirsutella Besseyi Fisher.—It has been observed that occasionally large numbers of first instar purple scales, typically white in color, become yellow and a high mortality follows. Following periods of high mortality, *H. Besseyi* has been found to be consistently associated with the dead nymphs. Whether or not this fungus is actually responsible for the periodic epizootics of young purple scales remains to be proved. However, if it is not the causal parasite, it appears to be a specific indicator of one particular disease of purple scales.

RUST MITES.—Yothers & Mason (1930) reported that following a period of maximum infestation of rust mites, *Phyllocoptruta oleivora* (Ashm.), on non-sprayed trees in June and July, the mites disappeared very rapidly, and that by the middle of September a diligent search was required in order to find even single specimens. Fisher *et al.* (1949) noted that between August and November, 1948, the per cent of infested fruit on non-sprayed grapefruit trees decreased from 98 to 16. They also reported a disease of the mites which corresponds with a disease described by Speare & Yothers (1924). Rust mites which were alive, but definitely abnormal in color and sluggish in their movements were found to be partially or completely filled with endoparasitic hyphal bodies. No hyphal bodies were found in normal rust mites. Following the occurrence of large numbers of off-colored mites, a high mortality resulted in the rust mite population. A fungus consistently associated with dead mites has been described as *Hirsutella Thompsonii* Fisher.

The means of infection of the rust mites by the endoparasitic hyphal bodies is unknown. It remains to be proved whether *Hirsutella Thompsonii* actually originates from these hyphal bodies in the living mites. If *H. Thompsonii* is not a true parasite, it seems to be a specific indicator of an economically important disease of the rust mites.

SUMMARY AND CONCLUSION.—At the present time, it may be concluded that one fungus, *Myiophagus* sp. Thaxter, is a true parasite and is acting as a factor in the biological control of purple and Florida red scales on Citrus in Florida.

No evidence has been found that the red-headed fungi, *Sphaerostilbe aurantiicola* (Berk. and Br.) Petch, *S. flammea* Tul., and *Nectria diploa* Berk. and Curt. are parasitic on red and purple scales.

Two recently discovered fungi, *Hirsutella Besseyi* Fisher and *H. Thompsonii* Fisher, may be parasitic, on purple scale nymphs and rust mites respectively; however, the parasitism of these two fungi remains to be proved.

LITERATURE CITED

Berger, E. W. 1910. Report of entomologist. Florida Agr. Expt. Sta. Ann. Rept.

Berger, E. W. 1921. Natural enemies of scale insects and whiteflies in Florida. Florida State Plant Board Quar. Bul. 5: 141–54.

Berger, E. W. 1932. The latest concerning natural enemies of citrus insects. Florida State Hort. Soc. Proc. 45: 131–6.

Earle, F. S. 1899. Orchard notes. Albama Agr. Expt. Sta. Bul. 106.

Fawcett, H. S. 1912. The effects of spraying. Florida Agr. Expt. Sta. Ann. Rept.

Fawcett, H. S. 1936. Citrus diseases and their control. 2nd Ed. Rev. McGraw-Hill, New York.
Fisher, F. E. 1950. Two new species of *Hirsutella* Patouillard. Mycologia. **42:** 290–7.
Fisher, F. E., J. T. Griffiths, Jr., and W. L. Thompson. 1949. An epizootic of *Phyllocoptruta oleivora* (Ashm.) on Citrus in Florida. Phytopathology **39:** 510–2.
Fisher, F. E., W. L. Thompson, and J. T. Griffiths, Jr. 1949. Progress Report on the fungus diseases of scale insects attacking citrus in Florida. Florida Entomologist **32:** 1–11.
Forbes, S. A. 1899. Recent work on the San Jose scale in Illinois. Illinois Expt. Sta. Bul. **56.**
Griffiths, J. T. and F. E. Fisher. 1949. Residues on citrus trees in Florida. I. Changes in insect populations following the use of different chemical materials used at the same amounts of residue per 100 gallons of spray. JOUR. ECON. ENT. **42:** 829–33.
Hayman, W. P. 1934. Effects of zinc sulfate on frenched Citrus in Polk County. Citrus Industry 15(11): 10–26.
Hill, S. B., Jr., W. W. Yothers and R. L. Miller. 1934. Effect of arsenical and copper insecticides on the natural control of whiteflies and scale insects by fungi on orange trees in Florida. Florida Entomologist **18:** 1–4.
Holloway, J. K. and T. R. Young. 1943. Influence of fungicidal sprays on entomogenous fungi and on the purple scale in Florida. JOUR. ECON. ENT. **36:** 453–7.
Karling, J. S. 1948. Chytridiosis of scale insects. Amer. Jour. Bot. **35:** 246–54.
Miller, R. L. 1937. The control of scale insects on Citrus. Florida State Hort. Soc. Proc. **50:** 100–6.
O'Byrne, F. M. 1916. Insects and diseases from a nursery inspector's viewpoint. Florida State Hort. Soc. Proc. **29:** 51–8.
Petch, T. 1921. Studies in entomogenous fungi. I. The Nectriae parasitic on scale insects. Brit. Mycol. Soc. Trans. **7:** 89–167.
Rolfs, P. H. 1897. A fungus disease of the San Jose scale. Florida Agr. Expt. Sta. Bul. **41.**
Rolfs, P. H. and H. S. Fawcett. 1908. Fungus diseases of scale insects and whitefly. Florida Agr. Expt. Sta. Bul. **94.**
Speare, A. T. and W. W. Yothers. 1924. Is there an entomogenous fungus attacking the citrus rust mite in Florida? Science **60:** 41–2.
Spencer, H. and M. R. Osburn. 1938. Citrus insect projects at the Orlando laboratory. JOUR. ECON. ENT. **31:** 728–30.
Thompson, W. L. 1938. Some possible reasons for the increase of purple scale infestation. Citrus Industry **19**(12): 6–7.
Thompson, W. L. 1939. Cultural practices and their influence upon citrus pests. JOUR. ECON. ENT. **32:** 782–9.
Thompson, W. L. and J. T. Griffiths, Jr. 1949. Purple scale and Florida red scale as insect pests of Citrus in Florida. Florida Agr. Expt. Sta. Bul. **462.**
Watson, J. R. and E. W. Berger. 1937. Citrus insects and their control. Florida Agr. Expt. Sta. Bul. **88.**
Webber, H. J. 1897. The new method of warfare against scale insects. Florida State Hort. Soc. Proc. **10:** 53–8.
Winston, J. R., J. J. Bowman, and W. W. Yothers. 1923. Bordeaux-oil emulsion. U.S.D.A. Bul. **1178.**
Yothers, W. W. and A. C. Mason. 1930. The citrus rust mite and its control. U.S.D.A. Tech. Bul. **176.**
Ziegler, L. W. 1949. The possible truer status of the red-headed scale fungus. A preliminary report (1935). Florida Entomologist **32:** 151–7.

Orchard Mite Control Experiments in Western New York[1]

P. J. CHAPMAN and S. E. LIENK,[2] *New York State Agricultural Experiment Station, Geneva, N. Y.*

At least four species of tetranychid mites now occur in western New York orchards. These are: the European red mite *Paratetranychus pilosus* (C. & F.); the two-spotted spider mite, *Tetranychus bimaculatus* Harvey; the clover mite, *Bryobia praetiosa* Koch and a recently described (McGregor 1950) new species of *Septanychus*. The present report will be limited essentially to the first and second species named, since these are the ones that are generally recognized as being orchard pests in this area at present.

The measures that have been used to combat mites heretofore, have been directed primarily against the European red mite. These have consisted of a dormant or semi-dormant applied ovicide to kill the winter eggs, followed, if necessary, by the use of one or more applications of an acaricide in the summer. There is apt to be a reversal of emphasis now between summer and dormant spraying owing to the increased importance of *Tetranychus bimaculatus*. This species overwinters as an adult and is little affected by current dormant treatments. Prior to 1946 when DDT was first used extensively by New York growers, the two-spotted mite was virtually unknown in our tree fruit plantings. It is now a common and increasingly important orchard pest. Circumstantial evidence strongly suggests

[1] Journal Paper No. 818, New York State Agricultural Experiment Station, Geneva, N. Y., January 11, 1950.
[2] The writers were assisted in these investigations by Miss Gertrude Catlin and Mr. Orion Clark.

that DDT created this problem, but it is not clear how this may have been effected.

The use of acaricidal treatments in western New York has been restricted generally to apple and plum orchards. Heavy infestations of *Paratetranychus pilosus* and *Tetranychus bimaculatus* appeared in peach and cherry orchards in 1949 and growers ultimately may need to use control measures in these plantings especially in sour cherry orchards.

BIOLOGICAL.—Eight generations developed in the case of both *Tetranychus bimaculatus* and *Paratetranychus pilosus* in 1949. Only the first four however, were complete generations or approached this condition. Since the growing season of 1949 was longer than usual for this area, it seems likely that there might be only seven generations in an average season, especially for *P. pilosus* which has a slightly slower rate of development than *T. bimaculatus*.

A record of the seasonal variations in mite populations that occurred in some local apple trees is shown in figure 1. These trees received no dormant or summer acaricides in 1949. Samples of leaves were taken from the same trees and at weekly intervals throughout most of the growing season. Each sample, composed of 25 leaves, was collected into a cylindrical pint paper food container and fumigated immediately by adding, before closure, about 1 cc of ethylene dichloride to a 2 or 3 inch length of dental wicking which had been affixed to the lid of the container. The mites were removed from the leaves for counting by using a Henderson (1943) brushing machine.

The population patterns shown in figure 1 are believed to be fairly typical for both *Tetranychus bimaculatus* and *Paratetranychus pilosus* in this area. Thus the European red mite is active early in the season and the two-spotted spider mite later. As noted here, and seen in many earlier observations, European red mite populations will build up to a maximum of about 150 hatched mites per leaf and then fall away suddenly. It has been generally supposed that this dramatic decline is simply a result of starving: the leaves suddenly become unable to provide the kind or quantity of food required. Obviously there will be some variations from the population pattern shown here from orchard to orchard, but, the writers believe not in any essential aspect. The records given in figure 1 show the mite population in the trees. *T. bimaculatus* was present and actively breeding on the ground cover (bindweed, etc.) under these trees until late July but did not appear in the tree in numbers until August.

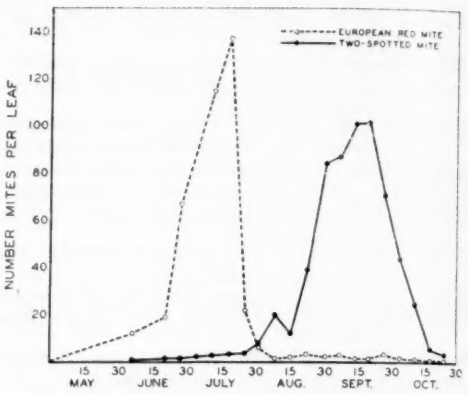

FIG. 1.—Seasonal variations in the population of hatched forms of the European red mite and two-spotted spider mite in the same apple trees, Geneva, N. Y. 1950.

European red mite ovicide tests.—Chapman & Pearce (1949) have reported the results obtained in 1948 with dormant and semi-dormant applied petroleum oil and dinitro compound sprays in killing the winter eggs of the European red mite. Except for the inclusion of two new materials, the same experimental methods and materials were employed in 1949 as in 1948. The more pertinent data obtained are given in table 1.

Results comparable with those given in the earlier paper cited are found in table 1 under the heading "indicated initial kill of eggs." These data confirm those obtained in 1948 except the dormant applied series of oil sprays proved more efficient in 1949. A possible explanation of this result is that the winter of 1948-1949 was unusually mild and consequently the eggs may have been farther advanced embryologically, thus being more susceptible to treatment. As shown here and in tests not reported, dinitro amyl phenol proved as effective as dinitro sec. butyl phenol in killing mite eggs.

In addition to the data obtained directly on the hatching rate of eggs, leaf samples were taken to determine the mite populations that developed in each plot. These data are included in table 1. Some

inconsistency will be seen here between the two methods used to measure results. Thus even though the indicated initial kill of eggs is much alike for the sprays containing the higher concentrations of both oil and dinitro preparations, mite populations built up more rapidly in the dinitro than in the oil plots. Measured on the latter basis the degree of control obtained with any of the dinitro treatments did not exceed that obtained with 0.25 per cent oil (see August 26 and 27 sampling).

Mite populations receded rapidly by early August in all plots regardless of the population level. No explanation can be offered at present for this occurrence although it has been noted before under similar circumstances. Prior to this overall decline the trends were definite. According to various reports, growers in the northeastern states generally had better results in 1949—strikingly better in some cases—with oil sprays than with dinitro sec. butyl phenol in providing early protection against European red mite.

The present hypothesis held by the writers to account for this difference is that while both materials are effective in killing the eggs at recommended dosage levels, petroleum oil sprays may provide a more complete coverage of the entire tree with identical spraying because of the peculiar properties of oil. If true this would result in a higher total kill of eggs on the tree. Ultimately, such a difference would be reflected on the mite populations that would develop later in the season. On the other hand, this condition might not be revealed in the hatching rate data owing to the kind of wood used in the sample. This was spurwood taken from inside the tree and 5 to 7 feet from the ground. Presumably such growth from its location and nature would be well covered in all sprayings.

SUMMER TESTS.—Twelve materialss were tested under orchard conditions in 1949 to determine their effectiveness in combating summer infestations of mites. Identification of 10 of the materials used and details of the tests conducted are presented in tables 2, 3 and 5. The products tested will be referred to in the text by their trade-name or code number owing to the length of the chemical names of the toxicants present.

With one exception, the materials were evaluated through the use of single treatments. Results were based on examinations of leaf samples taken at these intervals following treatment; 2 or 3 days, 9 or 10 days, and one or more later samplings. The 2 to 3 day count will provide a measure of the immediate effects of the material or its action against hatched forms. Since the incubation period of mite eggs in midsummer is usually of about 7 or 8 day duration, the 9 or 10 day count should show the total effects of a treatment. That is, it will show immediate action plus ovicidal or residual action. Theoretically these two records should provide the essential information needed for the preliminary evaluation of a material. At least one additional population sampling beyond 10 days has usually been made however, to measure any delayed effects. In the case of *Tetranychus bimaculatus* such a record is useful to determine whether or not the residual action of the product is of sufficient duration to prevent reinfestation from the ground cover.

Mite populations in the summer are seldom static. Therefore, the reudctions shown in tables 2, 3, and 4 are based on the numbers of mites that were present in control trees the day the treated plots were sampled.

The data presented in tables 2 and 3 were obtained by a direct examination of a freshly collected sample of leaves out in the orchard. Stereoscopic microscopes were employed and in most cases three observers took the records. The number of leaves examined per plot was 30, comprising three independently selected and examined sub-samples of 10 leaves each. A detailed record was taken on the developmental stage and species of all living mites present. Whatever the limitation of this method may be in extent, would appear to be more than compensated for in accuracy. This technique seems especially applicable to making observations on the acaricidal action of materials during the first 72 hours or so following treatment and in critical studies generally.

Experiments were conducted in three separate apple orchards in 1949 and in two sour cherry orchards occurring on the same farm. Treatments in all tests were applied with the same equipment which was a standard motorized hydraulic orchard sprayer. Test plots consisted of unreplicated blocks of two trees each.

Table 1.—Efficiency of dinitro compounds and of petroleum oil against winter eggs of the European red mite. 1949.

Toxicant and Concentration		Date Sprayed[1]	Indicated Initial Kill of Eggs	Number Hatched Mites per 100 Leaves				
				June		July		August
				9–10	29–30	13–14	26–27	16
DN-289[2]	0.125%	3/22	68.3%	528	2188	15,656	6624	80
DN-289[2]	0.25	3/22	94.4	214	716	5,712	6272	48
DN-289[2]	0.5	3/22	98.2	20	370	2,592	3584	102
DN-289[2]	0.75	3/22	98.9	18	260	2,162	3648	208
DN-289[2]	0.5	4/4	99.0	28	154	1,770	4080	240
Elgetol 50[3]	0.5%	3/23	97.3%	—	826	2,458	4384	64
Elgetol 250[4]	0.5	3/23	98.9	—	298	1,080	7568	16
Petroleum oil[5]	1.0%	3/24	75.0%	90	496	1,512	4000	112
Petroleum oil[5]	2.0	3/24	93.4	38	50	768	2592	288
Petroleum oil[5]	3.0	3/24	98.1	6	36	192	848	608
Petroleum oil[5]	4.0	3/24	98.9	0	42	254	1024	224
Petroleum oil[5]	0.25	4/23	84.3	152	602	3,008	3440	160
Petroleum oil[5]	0.5	4/23	89.9	90	144	840	2384	128
Petroleum oil[5]	1.0	4/23	93.2	36	156	766	1776	272
Petroleum oil[5]	2.0	4/23	96.7	10	40	822	1152	448
Petroleum oil[5]	3.0	4/23	99.6	6	6	158	496	896
Petroleum oil[5]	1.0	5/3	—	6	36	192	848	608
Controls				1509	2949	14,814	1148	272

[1] Bud stages on treatment dates were 3/22-24 dormant; 4/4 late silver tip; 4/23 delayed dormant, and 5/3 full pink or just prior to bloom.
[2] Triethanolamine salt of dinitro-sec. butyl phenol; contains approx. 21.5% of the acid. Dow Chemical Co.
[3] Triethanolamine salt of dinitro amyl phenol; contains approx. 21.5% of the acid. Standard Agricultural Chemical Co.
[4] Ammonium salt of dinitro amyl phenol; contains approx. 21.5% of the acid. Standard Agricultural Chemical Co.
[5] A "superior" type dormant tree spray oil. For specifications see JOUR. ECON. ENT. 42: 45, 1949.

Jenkins Orchard.—The mite population in this mature Rhode Island Greening apple orchard was restricted to the European red mite. Materials tested and the results of the tests are given in table 2. The usefulness of the data obtained here are limited: first, because the experiment was conducted during a period of rapid population decline, and secondly, lime residues persisting from a spray treatment applied 3 days prior to the initiation of the test by the grower may have reduced the effectiveness of such materials as DN-111, arathane and 88-R. Good immediate and residual action were obtained with experimental materials "EPN"[1] and EPN 923[2] and with parathion when used at 4 ounces actual parathion per 100 gallons. The immediate effects of C-854[3] were not impressive but showed a satisfactory kill by the 9-day count.

White Springs Farm (Cherry).—In one Montmorency sour cherry orchard on this farm the mite population consisted of moderate numbers of *Paratetranychus pilosus* and a light but uniform population of *Bryobia praetiosa.* In another planting there was a mixture of *P. pilosus* and *Tetranychus bimaculatus* with the latter species greatly predominating in the centers of the trees where the leaf samples were taken. The plan followed in this experiment was to spray a block of trees in each orchard thereby providing data on the response of three species of mites to the materials under the same testing conditions. Results are given in table 3. The high temperatures (table 4) that prevailed at time of spraying and in succeeding days probably were a factor in the results obtained.

In general, all species responded in much the same manner to the several acaricides tested with respect to immediate action. Poorer long range control of *Tetranychus bimaculatus* was obtained in some cases, owing apparently, to reinfestation from the ground cover. Results obtained with parathion confirm those obtained in the Jenkins experiment for European red mite, but even 4 ounces actual toxicant per 100 gallons failed to have much residual action against *T. bimaculatus* after 10 days. The two other organic phosphate products offered by the American Cyanamid Company proved

[1] Ethyl p-nitrophenyl thionobenzene phosphonate 31.5% (Dupont).
[2] 2,4-dichlorophenyl benzene sulphonate 50% (General Chemical Co.).
[3] p-chlorophenyl p-chlorobenzene sulfonate 50% (Dow).

Table 2.—Efficiency[1] of several acaricides against the European red mite. Host: apple. Jenkins orchard. 1949.

Toxicant and Amount per 100 Gallons	Per Cent Reduction in Population Days After 7/19 Spray			
	0	2	9	16
Parathion[2] 4 oz.	—	91.4	57.4	—
Parathion[2] 8 oz.	—	89.3	61.4	—
Parathion[2] 16 oz.	—	95.8	93.5	—
Arathane[3] 16 oz.	—	83.5	66.3	—
DN-111[4] 20 oz.	—	61.5	43.8	—
EPN[5] 8 oz.	—	97.3	99.8	100
TEPP[6] 8 fl. oz.	—	86.4	60.9	—
C-854[7] 32 oz.	—	76.5	94.4	—
88-R[8] 16 oz.	—	91.9	58.8	—
Material 923[9] 32 fl. oz.	—	94.2	98.4	—
	Ave. no. hatched mites per leaf			
Control	44	41	13	5

[1] A spray application applied by the grower July 16 contained lead arsenate 3 lbs. and hydrated lime 5 lbs. per 100 gallons. The presence of these lime residues may have affected the "normal" effectiveness of certain acaricides particularly DN-111, applied three days later.

[2] 25% 0,0-diethyl 0-p-nitrophenyl-thiophosphate. American Cyanamid Co.

[3] 25% dinitro-capryl phenol-crotonate. Rohm & Haas Co.

[4] 20% dicyclohexylamine. Salt of dinitro-o cyclohexylphenol. Dow Chemical Co.

[5] 31.5% ethyl p-nitrophenyl thionobenzenephosphonate. E. I. du Pont de Nemours Co.

[6] 20% tetraethyl pyrophosphate. California Spray Chemical Co.

[7] 50% p-chlorophenyl p-chlorobenzene-sulfonate. Dow Chemical Co.

[8] 15% β chloroethyl (tert. butyl phenoxy) α methyl ethyl sulfite. Naugatuck Chemical Div.

[9] 50% 2,4-dichlorophenyl benzene sulfonate. General Chemical Co.

superior to parathion in this latter respect with No. 3901[4] being the best of the three, judged both by immediate and long residual action. Again C-854 was found to be slow acting but ultimately gave a high rate of kill. There would appear to be no advantage in combining tetraethyl pyrophosphate with this product. The effect of hydrated lime in largely destroying the action of DN-111 is shown rather clearly in this test.

White Springs Farm (Apple).—The experimental block was comprised of mature apple trees of the Twenty Ounce variety and the mite population present was almost exclusively *tetrancyhus bimaculatus.* C-854 exhibited slower action than in the earlier tests. Also there was perhaps a greater differentiation in efficiency shown between the several concentrations of parathion tested. These effects may have been caused by the lower temperatures that prevailed in the present test (see Table 4). In interpreting these data it should be recognized further that these tests were conducted rather late in the season and when the trees were no longer subject to reinfestation from the ground cover.

SUMMARY AND CONCLUSIONS.—Although four species of spider mites occur in western New York orchards, only the European red mite and two-spotted spider mite are of general economic importance at present. Typically, the former species attains peak activity in midsummer, while the two-spotted spider mite first breeds on the ground cover and is not abundant in fruit trees until later in the season.

The following materials were found effective in killing winter eggs of the European red mite: a 2 per cent petroleum oil spray applied in the delayed dormant bud stage, and dormant application of dinitro sec. butyl phenol and dinitro

[4] 0,0-dimethyl S-(2-oxo-2-ureidoethyl) dithiophosphate (Am. Cyanamid).

Table 3.—Efficiency of several acaricides against three species of mites. Host: sour cherry. White Springs Farm. 1949.

Toxicant and Amount per 100 Gallons	Population Reduction, Per Cent, from August 9–10 Sprays								
	European Red Mite			2-spotted Mite			Clover Mite		
	Days After Treatment								
	2	10	25	2	10	28	2	10	25
Parathion[1] 4 oz.	99.8	60.8	75.4	90.7	38.6	—	96.2	73.9	50.0
Parathion[1] 8 oz.	100	94.7	85.2	95.0	88.2	—	98.4	93.9	66.7
Parathion[1] 16 oz.	99.8	99.3	96.9	97.8	83.7	0	98.4	98.2	100
No. 3869[2] 16 oz.	92.4	—	35.0	89.8	66.2	69.5	98.4	87.9	91.7
No. 3901[3] 16 oz.	96.3	85.2	98.0	92.3	97.2	92.5	100	98.2	100
EPN Miticide[4] 4 oz.	100	96.9	97.7	97.6	73.3	0	79.9	55.7	91.6
C-854[5] 32 oz.	61.7	97.2	97.8	83.7	92.7	93.6	22.2	71.5	100
C-854[5] plus TEPP[6] 8 fl. oz.	95.9	99.7	—	99.0	96.3	94.9	85.3	93.9	—
DN-111[7] 20 oz.	83.5	52.1	58.3	96.7	94.7	91.5	100	100	100
DN-111[7] plus hyd. lime 48 oz.	72.0	0	0	74.1	7.8	0	74.4	63.6	41.7
	Ave. no. hatched mites per leaf								
Controls:	17	11	15	37	43	60	1.8	1.6	1.2

[1] 25% 0,0-diethyl 0-p-nitro phenylthiophosphate. American Cyanamid Co.
[2] 25% S-carbamylmethyl 0,0-dimethyldithiophosphate. American Cyanamid Co.
[3] 25% 0,0-dimethyl S-(2-oxo-2-ureidoethyl) dithiophosphate. American Cyanamid Co.
[4] 31.5% ethyl p-nitrophenyl thionobenzenephosphonate. E. I. du Pont de Nemours Company.
[5] 50% p-chlorophenyl p-chlorobenzenesulfonate. Dow Chemical Co.
[6] 20% tetraethyl pyrophosphate. California Spray Chemical Co.
[7] 20% dicyclohexylamine salt of dinitro-o-cyclohexylphenol. Dow Chemical Co.

Table 4.—Temperature prevailing at time of treatment and subsequently in White Springs Farm Experiments. 1949.

A. Tests on Sour Cherry

	August									
	9	10	11	12	13	14	15	16	17	18
Max.	98	98	93	84	88	87	86	85	87	79
Min.	70	71	70	64	56	53	51	64	62	53

B. Tests on Apple

	August								
	23	24	25	26	27	28	29	30	31
Max.	88	75	84	93	95	89	69	82	80
Min.	54	45	56	63	67	64	52	59	60

amyl phenol preparations (containing approximately 21.5% toxicant as the acid) at 0.5 per cent strengths. Mite populations built up more rapidly in dinitro than in oil plots even though the indicated initial kill of eggs with the two materials was the same. Better kill of eggs throughout the tree because of superior coverage properties of oil is the hypothesis offered to account for this result.

The materials that were tested to determine their acaricidal value against summer infestations of mites included: seven organic phosphorous compounds, two dinitrophenols and three chlorinated products. The two-spotted spider mite proved more difficult to control than the European red mite and clover mite owing to reinfestation from the ground-cover. The three species exhibited essentially identical responses to the immediate effects of the various toxicants tested.

Parathion did not give consistently high immediate kill below 2 ounces actual toxicant (0.5 lbs. of 25 per cent powder) in 100 gallons. A 4-ounce dosage was needed to provide good residual action against European red mite or such action as might effect control from a single carefully applied treatment. A product containing ethyl p-nitrophenyl thionobenzenephosphonate gave results similar to parathion. Of all phosphorous materials used, only S-mercaptoacetylurea 0,0 dimethyldithiophosphate gave high extended protection against the two-spotted spider mite. Long residual action was also exhibited by p-chlorophenyl p-chlorobenzene-sulfonate. DM-111 (containing 20 per cent dicyclohexylamine salt of dinitro-o-cyclohexylphenol) was found to be largely inactivated as an acaricide in the presence of hydrated lime.

Table 5.—Efficiency of several acaricides against the two-spotted mite. Host: apple. White Springs Farm. 1949.

Toxicant and Amount per 100 Gallons	Date(s) Sprayed	Reduction in Population, Per Cent: Days after August 23 spray 3	8	15	28
Parathion[1] 4 oz.	8/23	85.7	27.0	67.4	68.6
Parathion[1] 8 oz.	8/23	94.8	61.5	79.0	80.7
Parathion[1] 1 lb.	8/23	94.1	91.6	93.2	97.6
Parathion[1] 2 lbs.	8/23	92.4	96.9	97.6	95.4
C-854[2] 1 lb.	8/23	0	50.8	74.9	84.5
C-852[2] 2 lbs.	8/23	9.1	84.2	88.9	94.8
TEPP[3] 8 fl. oz.	8/23	75.2	4.4	4.7	28.4
TEPP[3] 8 fl. oz.	8/23 9/2	75.2	4.4	93.5	95.0
Control: Ave. No. hatched mites per leaf		67	84	87	101

[1] 25% 0,0-diethyl 0-p-nitrophenolthiophosphate. American Cyanamid Co.
[2] 50% p-chlorophenyl p-chlorobenzene-sulfonate. Dow Chemical Co.
[3] 20% tetraethyl pyrophosphate. California Spray Chemical Co.

Literature Cited

Chapman, P. J. and G. W. Pearce. 1949. Susceptibility of winter eggs of the European red mite to petroleum oils and dinitro compounds. Jour. Econ. Ent. **42**: 44–7.

Henderson, Chas. F. and Horace V. McBurnie. 1943. Sampling technique for determining populations of the citrus red mite and its predators. U.S.D.A. Circ. **671**.

McGregor, E. A. Am. Midland Naturalist.

Mr. Avery S. Hoyt Becomes Chief of the "Bureau"

Mr. Avery S. Hoyt was appointed to succeed the late Dr. P. N. Annand as Chief of the Bureau of Entomology and Plant Quarantine, the appointment becoming effective on April 26, 1950. The Journal, on behalf of the entomologists of the country, extends congratulations to Mr. Hoyt.

DDT and Some of the Newer Insecticides for Control of Peach Tree Borers[1]

OLIVER I. SNAPP,[2] *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Driggers & Smith (1944) have reported a reduction in peach tree borers, *Sanninoidea exitiosa* (Say) in peach trees that were sprayed with DDT for control of the oriental fruit moth, *Graphloitha molesta* (Busck). The spray was directed at the foliage and fruit, no effort being made to spray the trunk and crotches or the around the trunk of the trees. The reduction in borers in the trees so sprayed was thought to have been due to the residue of DDT weathering from the foliage onto the larger limbs, crotches, and trunk.

Experiments with DDT and other newer insecticides for peach tree borer control have been conducted at the Fort Valley, Ga., laboratory of the Bureau of Entomology and Plant Quarantine since 1945. In addition, trees treated with DDT for plum curculio control in 1944 were examined in the spring of 1945 to determine the effect of the treatments on the peach tree borer. The results of these experiments are being reported here. Unless otherwise mentioned, all applications were made with a power sprayer to the trunks and lower part of large limbs of the trees. There was no preparation of the soil before treatment or other attention given the trees either before or after treatment except, where necessary, high grass and weeds were removed to prevent interference with the application of the spray to the trunks of the trees.

OBSERVATIONS ON EFFECTS OF DDT APPLIED IN 1944.—Trees that had been sprayed and dusted with DDT for plum curculio control in 1944 were examined on May 8 and 9, 1945, to determine the peach tree borer infestation. Trees sprayed with lead arsenate were also examined for borer infestation to provide a basis for evaluating the DDT treatments. There were as many live borers found in the trees sprayed or dusted with DDT as in those sprayed with lead arsenate, an indication that DDT as used for plum curculio control in 1944 had little if any effect in controlling peach tree borers. The applications may have been made too early to have much effect on the peach tree borer.

EXPERIMENTS IN 1945–46.—As insecticides for plum curculio or oriental fruit moth control must be applied in Georgia before there are many peach tree borer moths on the wing, an experiment was started late in the summer of 1945. DDT was applied at the rate of 2 pounds of the toxicant per 100 gallons of spray, on 5-year-old trees, at intervals during the oviposition period of the moths. The DDT formulation was a micronized 50 per cent DDT-pyrophyllite mixture. Fish-glue solution (1 pound of glue per gallon of water) was used at the rate of 1 pint per 100 gallons of spray to wet the mixture and stick it to the trees. Each treatment, including an untreated check, was replicated 5 times in randomized plats of 6 trees each. Three trees of each replicate were examined in the fall of 1945 and the other 3 trees were examined in the spring of 1946 for borer control and tree injury. The results of this experiment are tabulated below:

Dates of Treatment 1945	*Average Number of Live Borers per Tree*
August 2	1.8
August 2 and 31	1.0
August 2 and 31 and September 27	1.4
August 20	2.2
August 20 and September 17	2.8
Check (untreated)	3.8

DDT reduced the infestation but permitted the survival of too many borers to be considered practical for general use.

EXPERIMENTS IN 1946–47.—Since DDT applied to the trunk and lower part of large limbs of peach trees did not effectively control peach tree borers in 1945, tests were started late in the summer of 1946, in which the DDT was thoroughly applied to entire trees with a power sprayer during the oviposition period of the moths. The same DDT formulation and dosage were used as in 1945. DDT and benzene hexachloride dusts were also compared with the DDT sprays. The

[1] Presented at the meeting of the American Association of Economic Entomologists at Tampa, Fla., December 13–16, 1949.

[2] Julius P. Hollon assisted with some of the experiments reported in this paper.

dusts were applied with a hand duster to the trunk and larger lower limbs only of the trees and to the ground around the trees. The treatments and checks were replicated as in 1945, and examinations for borer control and tree injury were made in the fall and in the spring. The treatments tested and the results obtained are given in table 1.

Table 1.—Results of tests with DDT and benzene hexachloride for control of peach tree borers in 6-year-old trees 1946–47.

Treatment	Time of Application	Live Borers per Tree
	1946	*Number*
DDT spray (2 lb. of toxicant per 100 gal.	September 3	5.1
do	August 15 and September 15	6.0
do	August 2, September 3, and October 1	5.0
DDT dust, 10.8%	September 3	6.9
Benzene hexachloride dust (at least 5% of gamma isomer)	September 3	5.5
Check (untreated)		8.7

As in the 1945–46 tests, the treatments reduced the infestation but permitted too many live borers to remain in the treated trees. DDT and benzene hexachloride dusts were even less effective than DDT applied as a spray.

In an experiment conducted during the spring of 1947, 1 ounce of benzene hexachloride dust containing 1 per cent of the gamma isomer was applied around each test tree on March 31 in the same way that paradichlorobenzene crystals are used. The number of borers was reduced from an average of 4.8 per check tree to 2.1, or by 56 per cent. Such a reduction, however, cannot be considered adequate.

Experiments in 1947–48.—Further experiments to determine the value of DDT and some of the newer insecticides for peach tree borer control were started in the fall of 1947. The new materials used were benzene hexachloride, chlordane, toxaphene hexaethyl tetraphosphate parathion, and ryania. The treatments and checks were replicated as in 1945, and examinations for borer control and tree injury were made in the fall and in the spring (Table 2).

None of the materials prevented an infestation of the peach tree borer; however, benzene hexachloride and DDT showed promise.

In the spring of 1948 suspensions of

Table 2.—Results of experiments with DDT and some of the newer organic materials for peach tree borer control 1947–48.

Treatment[1] (Quantity per 100 Gallons)	Average Number of Live Borers per Tree	
	Four-year-old Trees	Five-year-old Trees
Benzene hexachloride (50% wettable powder containing 6% of gamma isomer), 8 lb.	1.61	0.2
Chlordane (47.2% wettable powder), 2 lb.	7.8	2.8
Toxaphene (25% wettable powder), 4 lb.	4.1	2.4
DDT (50% wettable powder), 8 lb., plus fish-glue solution 1 pt.	2.6	1.2
Hexaethyl tetraphosphate, 1 pt.	6.6	2.6
Parathion (25% wettable powder) 2 lb.	3.4	1.1
Ryania, 4 lb.	3.9	3.1
Check (untreated)	6.8	3.7

[1] Applied September 1 and 2 1947.

DDT and benzene hexachloride were poured around the base of trees and covered with soil in a manner similar to that used with paradichlorobenzene. Wettable powders containing 50 per cent of DDT or 6 per cent of the gamma isomer of benzene hexachloride were used at the rate of 10 pounds to 10 gallons of water and 0.5 and 1 pint were applied per tree. Neither of these treatments was effective.

Experiments in 1948–49.—Further experiments were started with DDT and benzene hexachloride late in the summer of 1948 in which these insecticides were used at greater strengths or in more frequent applications than previously. Both materials were used at the rate of 4 pounds of the toxicant per 100 gallons of water and were applied two or three times to four bearing peach orchards near Fort Valley, Ga. Additional tests were conducted to determine the comparative effectiveness against the peach tree borer of commerically manufactured emulsions containing propylene dichloride or ethylene dichloride and paradichlorobenzene and hexachloroethane crystals. Two of the four bearing peach orchards used in these tests were the same as those used for the previous experiments.

Each spray treatment that called for three applications was replicated five times in randomized plats of five trees each, and each treatment that called for two applications was replicated twice in randomized plats of five trees each. There were five randomized replicates of five check trees in each of the orchards. All trees were examined in the spring of 1949 for borer control and tree injury.

The emulsions were applied by pouring each dose on the soil around the base of the tree in such a way that the soil absorbed and held the chemical around the tree at the ground line. The soil level was raised before treatment where there were signs of borers in the tree above the normal soil level. A little soil was placed on the treated surface to prevent surface loss of the materials. When the crystals were used, the soil level was also raised before treatment where there were signs of borers in the tree above the normal level of the soil, and the trees mounded after the crystals were applied. Each treatment was replicated five times on randomized plats of six trees each with five randomized replicates of six check trees in each orchard. Three trees of each replicate were examined in the fall of 1948 and the other three trees were examined in the spring of 1949 for borer control and tree injury.

The treatments tested and the results obtained, are given in table 3. The figures for the fumigant-type treatments are the combined results of the fall and spring examinations.

Benzene hexachloride and DDT sprays applied two or three times during the oviposition period were about equally effective against peach tree borer moths in orchards in which the untreated trees averaged less than two borers per tree and gave fair to good control in orchards with heavier infestations. In the orchard most heavily infested the average borer population per tree was lower in the trees sprayed with benzene hexachloride than in those sprayed with DDT and lower in the trees receiving three applications than in those receiving two applications.

Hexachloroethane crystals were inferior to the benzene hexachloride and DDT spray treatments, as well as to the propylene and ethylene dichloride emulsions and paradichlorobenzene crystals. Records taken late in the fall of 1948 indicated that propylene dichloride emulsion may be a little more rapid in its action than ethylene dichloride emulsion or paradichlorobenzene at the strengths at which these materials were compared, but the following spring these treatments were about equally effective, the differences in the average borer population per tree being small and not consistent.

In the orchards in which the untreated trees averaged less than two borers per tree, the spray treatments were fully as effective as the fumigant-type treatments; however, the records secured when the borer population was heavier indicated

Table 3.—Results of experiments for peach tree borer control, 1948–49.

TREATMENT (QUANTITY PER 100 GALLONS OR PER TREE)	DATE OF APPLICATION, 1948	AVERAGE LIVE BORERS PER TREE					
		Orchard Number and Age of Trees					
		1 (4)[1]	2 (4)	3 (4)	4 (5)	5 (5)	6 (6)
Benzene hexachloride (50% wettable powder containing 6% of the gamma isomer), 8 lb.	August 6 and September 2	0.10		0	0.70	0.10	
	August 6, September 2 and October 6	.04		0	.44	.32	
DDT (50% wettable powder), 8 lb.	August 2 and September 1	0		0	1.30	.80	
	August 2–6, September 1–2, and Oct. 6	.04		.08	.68	.72	
Check (untreated)	—	1.12		1.28	4.56	2.21	
Propylene dichloride emulsion, ½ pt. of 10%	October 25–27		0.10		.03	.03	0.40
Ethylene dichloride emulsion, ½ pt. of 20%	October 25–27		.13		.40	.07	.50
Paradichlorobenzene crystals, ¾ oz.[2]	October 25–27		.10		.17	.20	.43
Hexachloroethane crystals, ¾ oz.[2]	October 25–27		.33		.97	.23	2.20
Check (untreated)			3.20		3.73	1.10	4.13

[1] Numbers in parentheses indicate age of trees.
[2] 1 oz. per tree used in orchard 6.

that the fumigant-type treatments may be more dependable although they did not consistently reduce populations to a markedly lower level than three spray applications of benzene hexachloride. The benzene hexachloride would be expensive, however.

None of these treatments caused any injury to the trees or crop.

SUMMARY.—In experiments conducted at Fort Valley, Ga., from 1945 to 1949, DDT, directed at the fruit and foilage of peach trees for plum curculio control, had little effect in controlling the peach tree borer. Treatments consisting of a single application of DDT or benzene hexachloride dust applied to the trunk and lower part of the large limbs of peach trees or benzene hexachloride dust applied in a continuous band around the tree and covered with soil were not effective against the insect.

Single applications of benzene hexachloride, chlordane, toxaphene, DDT, hexaethyl tetraphosphate, parathion, and ryania sprays to the trunk and lower part of large limbs of peach trees did not give effective control of the peach tree borer. DDT and benzene hexachloride suspensions poured around the base of peach trees and covered with soil were also ineffective.

Benzene hexachloride (6 per cent of gamma isomer) or DDT (50 per cent), 8 pounds per 100 gallons of spray, applied to the trunk and lower part of large limbs of peach trees during the oviposition period of peach tree borer moths gave effective control of that insect. They were also as effective as fumigant-type treatments in tests in which untreated trees averaged less than 2 live borers per tree the spring following treatment. The records secured when the borer population was heavier indicate that the fumigant-type treatments may be more dependable although they did not consistently reduce populations to a markedly lower level than three spray applications of benzene hexachloride. Against the lighter infestations benzene hexachloride and DDT sprays were about equally effective in schedules involving two or three applications. Against the heavier infestations benzene hexachloride showed to better advantage than DDT and, when used in three applications, was almost as effective, if not as effective, as recommended fumigant-type treatments. Hexachloroethane crystals were inferior to the benzene hexachloride and DDT spray treatments, as well as to the propylene and ethylene dichloride emulsions and paradichlorobenzene crystals. Propylene and ethylene dichloride emulsions and paradichlorobenzene crystals were about equally effective, no one of these treatments being consistently superior to the others at the strengths at which they were compared. Indications were, however, that propylene dichloride emulsion, as used, kills a little faster than ethylene dichloride emulsion or paradichlorobenzene. None of these materials caused injury to the trees or crop.

LITERATURE CITED

Driggers, Bryley F., and Charles L. Smith. 1944. Field tests of DDT to control of the peach tree borer. JOUR. ECON. ENT. 37(4): 537.

DR. CORY HONORED

Dr. E. N. Cory, Secretary-Treasurer of the Association was presented with the "Gold Medal of Achievement" for "Outstanding contributions to the development of orchidology" by the American Orchid Society which met at the Brooklyn Botanical Garden on June 13, 1950.

The medal was presented in recognition of the interest Dr. Cory has long held in the culture of orchids and his contributions in the field of control of insects affecting cultivated orchids in which his work has been outstandingly successful.

Dr. Cory attended the meeting and received the medal in person.

A Radiobiological Study of Four Organic Phosphates

C. C. Roan, H. E. Fernando and C. W. Kearns[1]

The insecticidal organic phosphates and their analogues and homologues are exceptionally well suited for the application of radioactive tracer techniques to toxicological studies of their effects on selected test organisms. The ready availability of the radioactive isotope of phosphorus, P32, and the relative ease with which this isotope may be incorporated in the molecules of such compounds as tetraethyl pyrophosphate and 0,0-diethyl-0, *p*-nitrophenyl phosphate makes radiobiological studies a valuable tool in investigating their mode of action.

We have been successful in preparing four such organic phosphates[2] tagged with P32,[3] tetraethyl pyrophosphate, 0,0-diethyl-0, *p*-nitrophenyl phosphate, tetraisopropyl pyrophosphate, and tetra-*n*-butyl pyrophosphate. These compounds have been employed in an investigation of their permeabilities, transport and metabolism in the American roach, *Periplaneta americana* (L.).

Chemical Synthesis.—The details of the microchemical syntheses of these compounds will appear elsewhere. Physical data, *i.e.* index of refraction, density and bioling points were not determined for the radioactive products. However, such data obtained on products obtained in preliminary microsyntheses employing the stable isotope indicated a purity of greater than 90 per cent for all four compounds. Comparative biological data obtained for tetraethyl pyrophosphate and 0,0-diethyl-0, *p*-nitrophenyl phosphate confirms the above figure.

Assay Equipment and Techniques.—Although the assay techniques employed were varied to meet the demands of the different phases of this study, certain general procedures will be described in this section while the modifications will be described in detail in the treatment of the separate phases.

Equipment.—A thin wall beta counter assembly (Radiation Counter Laboratories Mark 6 Model 3) was employed for all assays. This assembly consisted of a thin wall beta counter mounted in a plastic mount constructed so that the sample pans could be placed in selected, fixed positions giving a reproducible geometry to the sample pans.

This counter assembly was placed in a lead shield.[4] The outside dimensions of this shield were 15 by 5.25 inches with walls 1.5 inches thick. The inside was lined with graphite. A sliding door 15 by 5.25 by 1.5 inches, with the inner surface lined with graphite, provided access to the counter. The shield was provided with appropriate electrical connections to facilitate connecting the self quenching counter to the scaler.

The scaler was a Model 163 obtained from Nuclear Instrument and Chemical Corporation. In order to take advantage of the automatic features of this scaler, a Model T 1 dual timer was obtained from the same source. This combination allowed the operator to pre-select either the number of counts or the counting time, thus permitting more efficient utilization of the equipment and the operator's time.

In the first phase of the study porcelain capsules, Coors No. 1, were used for sample pans. This practice was abandoned when it became apparent that uniform decontamination was impossible. After this, aluminum sample pans, Radiation Counter Laboratories, Mark 5, Model 1 were employed and discarded after use.

Preparation of Samples.—The tissues to be assayed, entire insects or fractions thereof, were wet ashed with a minimum of concentrated nitric acid, filtered, and diluted to a constant volume. One milliliter aliquots were placed in the sample pans and slowly evaporated to dryness. This procedure eliminated the necessity of applying corrections for self absorption since the thickness of the sample in no case exceeded 10–15 mg./cm^2. Kamen (1947) states that P^{32} will not begin to be noticeably affected by self absorption until thicknesses of 15 to 20 mg./cm.^{2} are reached.

Counting.—Background counts were

[1] Contribution No. 292 from the Department of Entomology, University of Illinois, Urbana, Illinois.

[2] The authors are indebted to the Victor Chemical Works and particularly Dr. A. D. F. Toy for their advice and recommendations in the synthesis of these compounds.

[3] Radioactive phosphorus obtained from Oak Ridge National Laboratory, Division of Carbide and Carbon Chemical Corp., on authorization from the Atomic Energy Commission.

[4] Designed and constructed by the Department of Physics, University of Illinois.

Table 1.—Effects of solvents on rates of penetration from topical application.

Compound	Solvent	Per Cent of Dosage Inside Thorax and Abdomen After Application on Cervical Membrane			
		5 Min.	10 Min.	20 Min.	60 Min.
Tetra-*n*-butyl pyrophosphate	Propylene glycol	79	82	84	94
	Benzene	49	49	64	71
	Dioxane	53	58	62	73
	Ethyl alcohol	61	67	68	82
Tetraisopropyl pyrophosphate	Propylene glycol	74	74	75	83
	Benzene	52	50	52	58
	Dioxane	61	63	69	73
	Ethyl alcohol	57	72	83	84
Tetraethyl pyrophosphate	Propylene glycol	69	72	81	82
	Benzene	49	55	60	68
	Dioxane	80	85	91	98
	Ethyl alcohol	49	56	63	70
0,0-diethyl 0,*p*-nitrophenyl phosphate	Propylene glycol	65	79	86	88
	Benzene	51	65	68	73
	Dioxane	69	70	77	74
	Ethyl alcohol	72	74	76	76

taken at various intervals during each working day to determine the actual background and to check for any irregularities or counting chamber contamination.

The usual counting period was 16 minutes. Since most of the samples were very strong this counting period served to determine a counting rate with a standard deviation less than errors from non-statistical sources as recommended by Kamen (1947).

All counts were made at voltages well within the plateau of the counters used. Counting tubes were replaced at such a point in the investigation that the data obtained with one tube were not compared directly with that obtained from another counter.

Counting data obtained in any one series of experiments were corrected for decay ts a standard day arbitrarily selected for each experiment.

Effects of Solvents on Permeabilities.—Four solvents, propylene glycol, absolute ethyl alcohol, dioxane and benzene were used in this study. Sublethal concentrations of the four compounds were made up in the selected solvents and applied topically to the ventral cervical membrane in measured dosages in a manner similar to that proposed by Trevan (1922). The volume of solvent applied was 1 cubic millimeter. Anesthesia was not employed in any of the tests. Treated roaches were sacrificed at selected time intervals by freezing with crushed "dry ice." The head and neck regions were cut off and the thorax and abdomen wet-ashed with concentrated nitric acid and assayed as described above. The head and neck regions were removed so that the data presented in table 1 represents what was actually inside the thorax and abdomen of the roach. Ten roaches were used for each test which was replicated three times. In addition each test was duplicated, using either male or female roaches. The data in table 1 are therefore based on 60 roaches for each figure. We do not differentiate between the sexes here since no significant differences were observed. It is of interest to note that, in general, the slowest rate of penetration occurs when benzene is used as a solvent. Application of the compounds at minimum lethal dosages without the use of solvents is impractical because of the minute amount of the compound which is required. However, topical application of excessive doses of one cubic millimeter of 0,0-diethyl-0, *p*-nitrophenyl phosphate and tetraethyl pyrophosphate indicates a rapid penetration of such dosages without the use of a solvent.

From the data presented in table 1 it is apparent that the two relatively nontoxic compounds, i.e. tetraisopropyl pyrophosphate and tetra-*n*-butyl pyrophosphate, enter the body of the roach at rates comparable to those for tetraethyl pyrophosphate and parathion. Therefore perme-

ability is not a determining factor in the lack of toxic action of these two materials. The selection of a solvent to be used in topical applications can be of considerable importance as may be seen from these data. In testing a toxicant that may be rapidly detoxified by the test organism, the use of a solvent that gives a slow penetration rate could give considerable different results as compared with a solvent and toxicant combination which has a rapid rate of penetration.

The rates at which these compounds move throughout the body were determined following topical applications of sublethal concentrations in propylene glycol solutions to the ventral cervical membrane in the manner previously described. The roaches were sacrificed at selected time intervals and cut into the three body regions, *i.e.* head, thorax and abdomen. The data from this experiment are presented in table 2. It is important to note that in this case the values given for the head represent the per cent of dosage in or on the head region, whereas, those values given for the thorax and abdomen represent the percent of dosage distributed internally in these regions.

Table 2.—Rates of distribution through body from topical applications in propylene glycol solutions.

Compounds	Time After Treatment	Per Cent of Dosage Present in Body Region		
		Head[1]	Thorax[2]	Abdomen[2]
Tetraisopropyl pyrophosphate	5 min.	27	58	15
	10 min.	13	43	44
	20 min.	8	36	56
	60 min.	4	31	65
Tetraethyl pyrophosphate	5 min.	27	46	27
	10 min.	16	47	37
	20 min.	11	39	50
	60 min.	7	21	72
Tetra-*n*-butyl pyrophosphate	5 min.	22	57	21
	10 min.	14	44	42
	20 min.	11	39	50
	60 min.	8	27	65
0,0-diethyl-0,*p*-nitrophenyl phosphate	5 min.	40	47	13
	10 min.	22	60	18
	20 min.	12	49	39
	60 min.	13	34	53

[1] The values given in this column represent the percentage of total dose on or in the head.
[2] The values given in these columns represent the percentage of total dose distributed internally in these body regions.

From the data in table 2 it can be seen that the rates of transport throughout the body differ considerably for the four compounds. In all four cases there is a tendency for the radioactive materials to be concentrated in the abdominal region. The relative rates at which this concentration occurs are as follows: tetraethyl pyrophosphate > tetraisopropyl pyro-phosphate > tetra-*n*-butyl pyrophosphate > 0,0-diethyl-0, *p*-nitrophenyl phosphate. These rates fall in the same order as the water solubilities of these materials. This correlation might indicate that the means of transport is provided by the blood plasma of the roach. Preliminary qualitative tests indicated the presence of the radioactive materials in blood samples collected from treated roaches. We have not as yet been able to identify the fraction of the blood responsible for transport of these radioactive materials.

The results of this experiment indicate that the failure of tetraisopropyl pyrophosphate and tetra-*n*-butyl pyrophosphate to produce symptoms of intoxication at dosage levels comparable to the dosage levels of tetraethyl pyrophosphate which do produce mortalities is not due to lack of transport and general distribution. Although the rates of movement from the site of application are slower for tetraisopropyl pyrophosphate and tetra-*n*-butyl pyrophosphate, likewise the rate of excretion is considerably lower as may be seen from table 3. These data would tend to substantiate the theories of Ludvik[1] and Metcalf & March (1949) that certain conditions in regards to stereochemistry must be fulfilled before a phosphate compound will be an effective toxicant or inhibitor of cholinesterase.

It was observed that these materials were being voided from the roach with the fecal matter. Additional tests were conducted to determine the rate of excretion following topical application of sublethal dosages to the ventral cervical membrane. Roaches were treated in lots of 30 each with propylene glycol solutions of the four compounds. At various time intervals the fecal matter was collected and assayed for radioactive phosphorus. The data on the rate of excretion of these compounds are presented in Table 3.

It is of interest to note that the rate of movement through the body and more particularly the rate of escretion closely parallels the susceptibility of these compounds to aqueous hydrolysis, *i.e.* tetraethyl pyrophosphate > tetra-*n*-butyl pyrophosphate > tetraisopropyl phosphate > 0,0-diethyl-0,*p*-nitrophenyl phosphate.

[1] Unpublished doctoral thesis, University of Illinois.

Table 3.—Rate of excretion from topical application in propylene glycol solution.

Hours After Treatment	Per Cent of Dosage Excreted at Times Indicated			
	Tetraisopropyl Pyrophosphate 30 μg./Roach	Tetra Butyl Pyrophosphate 30 μg./Roach	Tetraethyl Pyrophosphate 15μg./Roach	0,0-diethyl-0,*p*-nitrophenyl phosphate 2 μg./Roach
5	6	6	11	—
10	22	36	48	10
22	32	52	72	32
34	42	74	85	38
46	46	85	90	44
58	56	89		—
70	66			50
82	78			

The fecal matter was extracted with various solvents in order to determine the possible chemical form of the excreted material. In the case of all four compounds it was impossible to extract the radioactive material with benzene, ether or absolute alcohol. The radioactivity could, however, be partially extracted with cold water and completely so with hot water. This observation led us to the conclusion that these organic phosphates are degraded inside the roach to an inorganic phosphate.

In investigating the possible route of excretion some preliminary studies were made with radioautographs of frozen sections which indicated that several hours after application the radioactive material was concentrated in the region of the rectum. However radioautographs of roaches, treated with lethal concentrations, sacrificed at the onset of symptoms of intoxication, (45 minutes to 1 hour) indicated a concentration of radioactive materials in the fore gut.

These observations led to the dissection of tissues from treated roaches to determine the actual site of concentration of these materials.

Metcalf & March (1949) demonstrated that tetraethyl pyrophosphate was an effective inhibitor of cholinesterase. This fact plus our observation that this compound was rapidly excreted led to the investigation of the concentrations in the region of the gut and the central nervous system. In preliminary studies on this particular phase it was observed that the toxicant, or its metabolic product, was concentrated in the region of the fore gut after a topical application, instead of the hind gut as would have been expected if the malpighian tubules were responsible for excretion.

To substantiate this observation the tissue concentration of tetraethyl pyrophosphate or its metabolites was determined at various time intervals following a topical application. The various tissues were dissected, rinsed rapidly in a large volume of water to remove any blood and treated with nitric acid prior to counting. Tissues from two roaches were combined for each test. The results of this test are shown in figure 1. The tissue weights used were an average weight of tissuse from five roaches. These figures are shown in table 4. The concentration of the radioactive material in the blood was determined by assaying a weighed amount of blood. From figure 1 it becomes apparent that the radioactive product is rapidly concentrated in the region of the fore gut with a relatively low increase in the concentration in the rest of the body. To determine relative concentration of radioactive materials in the tissues of the crop and in its contents, the crops of two roaches were dissected and the contents flushed out with water. The ratio of the radioactive material in the tissue to the radioactive material in the contents of the crop was 0.089, indicating that tetraethyl pyrophosphate not only makes a rapid entry into the body cavity, but it or its metabolites are actively taken up by the crop epithelium and rapidly secreted into the lumen of the crop. It should be noted that in these tests every precaution was taken to preclude the possibility of ingestion of any of the applied dosage.

In order to ascertain whether or not a high concentration of radioactive materials in the fore gut resulted from the

proximity of this structure to the site of application, the toxicant was administered on the intersegmental membrane between the sixth and seventh abdominal sterna.

The results of this test are shown in table 5. When these data are compared with those in figure 1 it is seen that the locus of administration of the toxicant has some effect on the concentration of this material in the various regions of the gut. However, it is clearly seen that the fore gut acts to concentrate selectively the tetraethyl pyrophosphate or some product of its degradation.

Table 4.—Tissue weights used in calculating tissue concentration of radioactive material.

TISSUE	WT. IN MGM.[1]
Fore gut	24
Mid gut	38
Hind gut	40
Central nervous system	5
Fat	60
Thoracic muscle and leg	320
Rest of body	240

[1] Average of five roaches.

A comparison was made of the distribution of the toxicant in affected roaches with its distribution in unaffected roaches. In this study two prostrate roaches and two unaffected roaches were selected from a group which had received the same treatment. Ten hours were allowed to elapse in order to be certain that the roaches selected as survivors would not be affected. After this time assays were made to determine the distribution of radioactive materials in the two groups. The data from this experiment are presented in table 6. From the data in this table it can be seen that the fore gut in the surviving roaches shows considerably higher concentrations than the fore gut of the prostrate roaches. Correspondingly lower concentrations are found in the muscle tissues of survivors than in the muscle tissues of prostrate roaches.

The fact that the radioactive materials were rapidly concentrated in the fore gut of the unaffected roaches may possibly explain their failure to succumb to the treatment. These observations would indicate that in this case the surviving roaches were able actively to secrete the toxicant or its metabolites into the lumen of the gut. The rate of this active uptake was sufficiently rapid to prevent the concentration of the toxicant in the blood and other tissues from reaching a level sufficient to produce any symptoms of intoxication. The affected roaches were apparently unable to remove the toxicant from the blood stream and other tissues at a sufficiently rapid rate.

We were unable to make any comparisons of the concentration of radioactive materials in the blood of prostrate and survivor roaches. Upon dissection of prostrate roaches which had been treated with topical application of tetraethyl pyrophosphate we observed that there were no liquid body fluids such as are observed on dissection of normal roaches. The usual technique in collecting blood samples was to cut one of the coxae and collect the exuding blood. However, in the case of prostrate roaches no such exudation was observed. A rhythmic contraction of heart could be observed even at 4 hours after prostration although there was no apparent circulation.

Table 5.—Concentration of radioactive materials in tissues following topical application with tetraethyl pyrophosphate to intersegmental membrane between sixth and seventh abdominal sterna.

TISSUE	30 MIN. AFTER TREATMENT CPM./MGM. TISSUE
Fore gut	8.8
Mid gut	0.42
Hind gut	0.98
Central nervous system	Background
Fat body	0.57
Thoracic muscles and legs	0.88
Rest of body	0.63

We have not presented in any of the tables data indicating the amounts of radioactive materials in the nervous system. This, however, should not be construed to indicate a complete absence of toxicant or of metabolite from this system. The counting data for the central nervous system was so close to the background level that it was of questionable value. This would not be surprising since the values for thoracic muscle were considerably less than one cpm./mgm. tissue. Even at this level the counts obtained from two complete nervous systems would have been but 10 cpm. Our failure to detect any radioactive materials in the

central nervous system may be explained by the fact that the specific activity of our tracer tetraethyl pyrophosphate had decayed to a very low level before this experiment was carried out.

SUMMARY AND CONCLUSIONS.—1. Tetraethyl pyrophospate, tetraisopropyl pyrophosphate, tetra-*n*-butyl pyrophosphate, and 0,0-diethyl-0,*p*-nitrophenyl phosphate were synthesized from radioactive phosphorus.

2. These tagged compounds were used in the following studies employing the techniques of radiobiological assays:

Table 6.—Relative concentrations of radioactive materials in tissues of prostrate roaches and survivors.[1]

SURVIVORS[3] CPM./MGM. TISSUE	TISSUE	PROSTRATE[2] CPM./MGM. TISSUE
3.9	fore gut	1.65
1.45	mid gut	0.84
1.0	hind gut	1.27
Background	central nervous system	background
0.27	fat	background
0.175	thoracic muscles and legs	0.35
0.23	rest of body	0.78

[1] Topical application to ventral cervical membrane of 30 μg. tetraethyl pyrophosphate in 1 mm.[3] acetone. Assayed at 10 hours after treatment.
[2] Prostrate for 8 hours.
[3] 42 per cent of the dosage had been excreted at time of assay.

a. Determinations of the effect of four solvents on the rates of penetration into the body of the American roach following topical applications on the ventral cervical membrane. (Dioxane, benzene, propylene glycol and ethyl alcohol.) The relative order of penetration at 60 min. is as follows: tetraethyl pyrophosphate-dioxane > propylene glycol > ethyl alcohol > benzene. Tetraisopropyl pyrophosphate-ethyl alcohol > propylene glycol > dioxane > benzene. Tetra-*n*-butyl pyrophosphate-propylene glycol > ethyl alcohol > dioxane > benzene. 0,0-diethyl-0,*p*-nitrophenyl phosphate-propylene glycol > ethyl alcohol > dioxane > benzene.

b. The rates of distribution throughout the body following topical applications of propylene glycol solutions are tetraethyl pyrophosphate > tetraisopropyl pyrophosphate > tetra-*n*-butyl pyrophosphate > 0,0-diethyl-0,*p*-nitrophenyl phosphate. This closely parallels the order of water solubilities of these materials.

c. The rates of excretion from the body following topical applications were of the following order: tetraethyl pyrophosphate > tetra-*n*-butyl pyrophosphate > tetraisopropyl pyrophosphate > 0,0-diethyl-0,*p*-nitrophenyl phosphate.

3. Tetraethyl pyrophosphate was employed in experiments to determine the tissue concentration of this tagged material, or its metabolite, following topical applications. The highest concentrations were found in the fore gut, with the concentration in the blood rising rapidly at first, then falling sharply. Slight increases were noted in muscle tissue during the first hour following treatment.

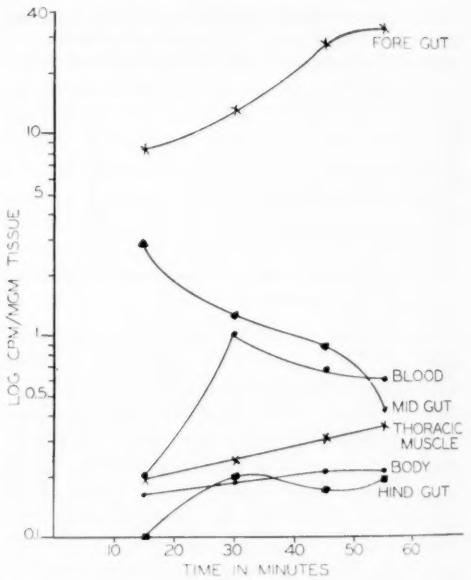

FIG. 1.—Concentration of radioactive material in tissues following topical application of TEPP to the ventral cervical membrane.

4. Both for sublethal and lethal administrations of tetraethyl pyrophosphate the fore gut exhibits a marked selective absorption of this material or its metabolites and a rapid secretion of this substance into the gut lumen. Concentrations of tetraethyl pyrophosphate in the tissues of roaches that survived a treatment when compared with those in tissues of prostrate roaches given the same treatment, showed the fore gut in roaches that survived held considerably higher concentrations of radioactive material, while the muscles of prostrate roaches held more of the same material than the survivors.

5. Although no radioactive materials

were detected in the central nervous system, the authors do not believe that this of necessity indicates a complete absence of such materials from this region since the specific activity of the tracer compound employed had deteriorated to rather low levels when this experiment was performed.

LITERATURE CITED

Kamen, M. C. 1947. Radioactive Tracers in Biology. Academic Press, N. Y. xiii+281 pp.

Metcalf, R. L. and R. B. March. 1949. Studies of the mode of action of parathion and its derivatives and their toxicity to insects. JOUR. ECON. ENT. 42(4): 721–8.

Trevan, J. W. 1922. An apparatus for the measurement of small quantities of fluid. Lancet (London), 202: 786.

Development of Gypsy Moth Sex-Attractant Traps

EMORY D. BURGESS,[1] *Bureau of Entomology and Plant Quarantine, Agr. Res. Adm., U.S.D.A.*

Control measures for most insect pests are usually not undertaken until populations have increased to levels that would cause almost complete destruction or certainly great economic loss to a particular crop or commodity. In gypsy moth, *Porthetria dispar* (L.), control and eradication work, however, the maximum effort is usually expended near the periphery of the infested area, where populations are, in general, extremely low. Many times it is difficult to determine the presence or absence of the gypsy moth near the boundaries of the generally infested area or at isolated spots where extermination is the purpose of the operation. The gypsy moth often is present at these sites in such low concentrations that it might not be discovered by other methods for years. Nevertheless, if left to increase normally these infestations could jeopardize nearby uninfested areas and make future control operation more extensive and, therefore, more costly.

In the early control work on this insect visual scouting methods were relied on almost entirely for determining areas where control measures should be taken. This was an expensive operation because of the manpower necessary for careful examinations of large tracts of forest lands and other tree growth. Obviously, as the infested area increased in size, either more and more personnel were needed to conduct this type of survey or the available personnel covered the territory more hurriedly, and, as a result, less accurately. It became necessary, therefore, to resort to other means of determining the approximate whereabouts of gypsy moth infestations in these lightly infested areas.

Late in the nineteenth century, Forbush & Fernald (1986) found that male gypsy moths would fly considerable distances to traps containing living virgin females. This early trap, known as the Shaw trap, was made of wood and consisted of a platform upon which a perpendicular structure in the form of a cross was erected (Fig. 1). On the base and in the center of this unit a screened cage was placed in which the virgin female moths

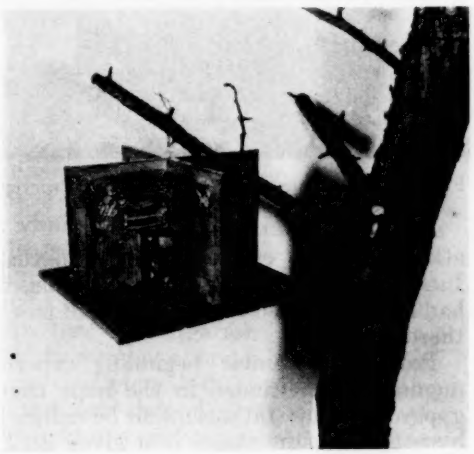

FIG. 1.—Shaw trap used in early gypsy moth assembling experiments.

[1] The author greatly appreciates the able assistance of Ralph F. Holbrook who made the field observations, and without whose efforts this study would not have been possible. He further appreciates the untiring efforts of Fred Acree, Jr., in improving the gypsy moth trapping activity and the helpful suggestions of R. C. Brown and S. F. Potts during the conduct of this work.

were contained. The base of this trap as well as the wings were coated with a sticky gum of crude resin and crude castor oil, which was applied while warm. The complete structure was suspended from a branch of a tree or other support. Even this crude trap was very effective in

FIG. 2.—Scouting trap used in gypsy moth survey work from 1942 to 1948.

attracting and capturing male moths. In some tests it was indicated that males had been attracted for a distance of more than half a mile.

From this humble beginning experiments were continued in the hope that gypsy moth infestations might be reduced by attracting the males in a given area, thus leaving the females unfertilized. They were soon abandoned, however.

Studies culminating in 1932 were conducted by Collins & Potts (1932) to determine whether extracts of virgin female moths could be substituted for the moths themselves and to explore various other problems related to assembling. In the course of these investigations it was discovered that if the last two abdominal segments of virgin female moths were removed, extracted in a commercial solvent such as benzene, and placed in a trap, male moths were attracted to them. This discovery was extremely important, because living females should not be placed in uninfested territory even for determining the status of gypsy moth infestation. The danger of accidentally creating additional outbreaks by the use of living material is too great.

At this stage in the development of the gypsy moth trap an extract from 30 abdominal tips was poured onto a cotton wad, which in turn was placed in a small tin container having no cover. This container was nailed to a tree in an inverted position so that the cotton holding the attractant would not be subjected to the direct effects of rain. The cotton was held in the can by the nail which attached the container to the tree. Tanglefoot was applied to the bark of the tree around the can, and it was on this sticky material that moths were caught when attracted to the trap. Later a treated paper cone was substituted for the can, and a waxed paper rather than the tree itself was coated with tanglefoot.

About 1936 S. F. Potts, of the Bureau of Entomology and Plant Quarantine, developed a cylindrical trap 6.5 inches in diameter and 12 inches long. This structure was fitted with conical ends of screening, at the apex of which was an entrance hole approximately 1 inch in diameter, with a baffle over it to prevent the escape of moths (Fig. 3). The bait material impregnated in cotton was placed in a screen cylinder, which was inserted into the side of the trap. It was found necessary to insert paper coated with tanglefoot around the inner surface of the cylinder in order to catch the moths attracted to the trap. Otherwise, even with the baffle, moths could escape. This trap was not used extensively owing to its cost and its size, which made it inconvenient to handle in large numbers.

Prior to 1930 assistance was sought from Harvard University to ascertain the chemical nature of the attractant and to produce a synthetic material. This work was not successful, and in 1941 a chemical study was renewed by Haller *et al.* (1944). They found that catalytic hydrogenation improves the bait material so much that the results in the field are the same when the tip requirements are reduced from 30 to 15. This advancement made it possible to bait twice as many traps

with the same amount of sex attractant.

In 1947 further experimental work was initiated to improve the material and equipment used in conducting the Bureau's trapping programs. In recent experimentation an attempt has been made to improve not only the design of the trap but the material on which the sex attractant is impregnated. Chemists in the Bureau have cooperated in analyzing the sex attractant with the ultimate purpose of producing a synthetic gypsy moth attractant.

At the end of the 1947 season a new trap was devised patterned somewhat along the lines of the Potts trap. This trap, known as the Graham trap (Fig. 4), consists of a metal cylinder 4 inches in diameter and 7 inches long with a rim at each end to which is attached a screen cone with a hole at the apex for entrance of the moths. The bait dispenser is suspended inside the cylinder by a wire, both ends of which protrude to the outside and are used to attach the trap to the support. This cylinder is lined with paper coated with tanglefoot to catch the moths attracted to the trap.

FIG. 3.—Potts trap.

The work in 1947 also indicated that impregnated cotton did not easily give off all the sex-attractant material available. Only the material near the surface of the cotton wad was readily disseminated. A bait dispenser of corrugated paper rolled into a cylinder 3 inches long by 1 inch in diameter produced far better results in all types of traps tested than did the cotton wad. This bait dispenser has been used in the field for three seasons with increasingly better results.

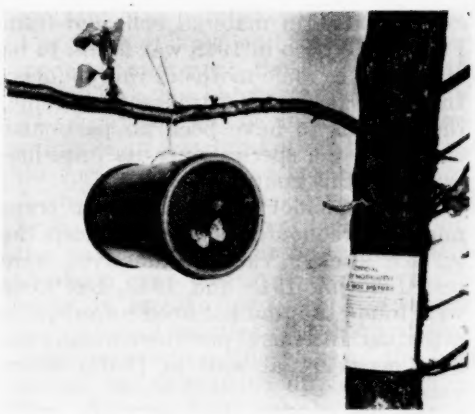

FIG. 4.—Graham trap used extensively in present gypsy moth surveys

During the last 2 years experiments have been carried on to perfect the gypsy moth trapping operations. Investigations were conducted to determine whether the strength of the bait could be further reduced by a better trap design. It is possible to capture male gypsy moths with as few as 2 tips per trap, but 15 tips per trap were necessary to attract the maximum number.

The effect of trap color on gypsy moth capture has also been investigated. It has been known, for example, that Japanese beetle traps painted yellow are more effective than those of other colors. Preliminary results with the gypsy moth indicate that, except for traps painted red or white, which seemed inferior, color is of little importance. Traps painted green, gray, yellow, yellow-orange, and orange caught equally well.

Another investigation was concerned with the number of hours it was necessary to age virgin female moths before clipping the last two abdominal segments. Moths were held in a cool environment and some were clipped every 8 hours up to 72 hours after emergence. The longer a moth was held before clipping the more effective was the extract from the abdominal tips. These results confirmed earlier experiments. Whether or not the material was hydrogenated seemed to make little difference. It has been considered impractical to hold moths more than 24 hours prior to clipping because their mortality increases greatly after that time. Tips clipped from dead moths were found to be ineffective.

As an interesting sidelight on these

experiments, tip material collected from French Morocco in 1948 was found to be attractive to male moths in this country. Inasmuch as this sex attractant is specific, there seems to have been no particular change in the species since its introduction into this country in 1869.

The tanglefoot coating in these traps must be frequently combed to keep the surface sticky. Various adhesives were tested during 1948 and 1949, but none were found that did not need considerable attention. In general practice combing has been necessary at least at 10-day intervals.

Many variations in trap design have been tested, but none seem to be more effective than the cylindrical trap. The relation of size of trap to moth capture has not yet been fully worked out, but it appears that sizes smaller than the Graham trap should not be considered. There is some variation in the results obtained with traps larger than the one presently in use, but here again one must weigh the difficulties involved in employing a larger trap in the field when an extensive trapping program is being carried on.

Investigations will be continued to improve this feature of the gypsy moth control work. The entire control program of this Bureau and cooperating State agencies is dependent upon the trapping surveys. During the 1949 trapping season approximately 7,000,000 acrea were surveyed by this method, and about 17,000 Graham traps were used. Since much larger acreages must be surveyed in the future, the value of continuing investigations on this phase of gypsy moth control can readily be seen.

LITERATURE CITED

Collins, C. W., and S. F. Potts, 1932. Attractants for the flying gypsy moths as an aid in locating new infestations. U. S. Dept. Agr. Tech. Bul. **336.**

Forbush, E. H., and C. H. Fernald. 1896. The gypsy moth, **Porthetria dispar** (L.). Mass. State Board Agr.

Haller, H. L., Fred Acree, Jr., and S. F. Potts. 1944. The nature of the sex attractant of the female gypsy moth. Amer. Chem. Soc. Jour. **66:** 1659–62.

Effect of Dichlorodiphenyl Dichloroethane on Larvae of the Clear Lake Gnat in California

A. W. LINDQUIST and A. R. ROTH, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

The Clear Lake gnat, *Chaoborus asticotopus* D. and S., a non-biting midge, has created a problem of considerable economic importance in the environs of Clear Lake, California. The tremendous numbers of these insects and their swarming around lights have caused tourists and others seeking rest and relaxation to avoid the area, and hindered its development as a recreational district.

Since the new insecticides were proving highly effective on mosquito larvae and other insects, the possibility of utilizing some of these materials for gnat control at Clear Lake stimulated the Lake County board of supervisors to request assistance from the Bureau of Entomology and Plant Quarantine U. S. Dept. of Agriculture. Numerous laboratory tests were made by Bureau workers in December 1946 and in June and October 1947. These tests demonstrated that larvae of the Clear Lake gnat are sensitive to all the new chlorinated hydrocarbon insecticides (unpublished results). One of the compounds, dichlorodiphenyl dichloroethane (TDE), was found to be effective on the gnat larvae and also less toxic to fish than DDT.

TESTS IN LOWER BLUE LAKE.—The encouraging results obtained in the laboratory tests suggested that TDE should be tested in a practical way on a small lake to determine whether gnat larvae would be destroyed. Because of the importance of the experiment and the possibility that TDE might be deleterious to fish and plankton, the California State Division of Fish and Game was asked to assist in the study. A co-operative arrangement was made whereby that agency studied the effects of the insecticidal

treatment on fish, plankton, and other organisms in Lower Blue Lake. The results of the study are presented in this paper. The Bureau of Entomology and Plant Quarantine applied the insecticidal treatment and studied the effects of the chemical on the bottom fauna, and the results obtained are presented here.

The Clear Lake gnat passes the winter in the larval stage in the lake, and adult emerge in the spring at water temperatures of 62° to 70° F. (Lindquist & Deonier 1942, 1943). Emergence reaches a peak in July and August and declines through September. The larvae spend the daylight hours embedded in the bottom mud but move up in the water at night. This movement is most pronounced during the summer months. In a larvicide test, therefore, the larvae are in contact with the treated water only during the night, and several exposures may be necessary to cause mortality.

Lower Blue Lake, located approximately 15 miles north of Clear Lake, was selected as the test area. This lake ranges in width from 500 to approximately 800 feet, is 3700 feet long, and covers 46 acres. It has a high population of gnat larvae and is similar to Clear Lake in many respects. The shore line is steep, and a water depth of 7 to 10 feet was found 15 feet from shore. The maximum depth was 21 feet. The volume of the lake was determined by taking numerous soundings and calculating the amount of water within each of the contours. The number of acre feet was 775.

From various laboratory tests it was found that an emulsion was more effective than either a wettable-powder or an oil preparation. It was believed that an emulsion with a specific gravity the same as that of water would be most effective. A formula containing 30 grams of TDE, 10 cc. of an aralkyl polyether alcohol,[1] and 72 cc. of xylene (crude) was developed as most likely to mix throughout the water and disseminate over the lake. The concentration used was 1 part of TDE to 45 million parts of water.

Lower Blue Lake was sprayed on November 7, 1947, with a gasoline-powered gear pump and a spray gun from which the whirl disk had been removed. The spray rig was placed in a 15-foot rowboat, which was powered with a 5-hp. outboard motor. The first batch of emulsion concentrate was diluted to approximately 5 per cent of TDE and four swaths were made up and down the long axis of the lake. The other batches were less dilute. The spray rod was inclined upwards and swung in an arc ahead of the boat so that the spray fell on the surface of the water. A straight stream was produced, which broke into large droplets before reaching the water surface. The milky insecticide emulsion was observed on and in the water in streaks to a depth of several inches for 15 minutes after the spraying. Small waves from the wake of the boat carried the insecticide up to the shore. The lake was glassy calm at the time of spraying, and the water temperature was 55° F. A series of bottom-mud samples were taken with a 6-inch square Ekman dredge at nine stations over the lake before treatment and at intervals after treatment. Counts were made of the *Chaoborus* larvae, as well as of various other dipterous larvae and Oligochaeta (aquatic worms).

Table 1 shows that *Chaoborus* larvae declined gradually in abundance and that control after 13 days was approximately 82 per cent and reached 100 per cent after 96 days. Bottom samples were not taken again until August 22, 1948 (288 days after treatment), when an average of 0.55 larva per sample was found. Samples taken from 302 to 536 days after treatment showed zero to 0.2 larva per sample. It is clear, therefore, that repopulation of the gnat in Lower Blue Lake is extremely slow, even though a continuous source of reinfestation is present from Upper Blue Lake approximately 800 feet away. It is possible that the fish in Lower Blue Lake contribute to the slow build-up by feeding on the few larvae that develop.

Chironomidae were greatly reduced within 2 days and were practically eliminated in 13 days. Of great interest, however, is the strong repopulation trend in these species. Larvae taken during each of five sampling periods several months after treatment of the lake, averaged from 0.2 to 0.5 per sample. After 536 days the average number per sample was 1.3. The percentage recovery and build-up was much greater than with the *Chaoborus* larvae.

The Oligochaeta showed no injury or reduction in numbers until 13 days after

[1] *Triton X-100.*

Table 1.—*Chaoborus* larvae and other aquatic organisms taken in 6-inch square samples of bottom mud before and after treatment with TDE on Lower Blue Lake, California. Lake treated on November 7, 1947.

Days Before and After Treatment	Number of Samples	*Chaoborus*		Average Number per Sample		
		Average per Sample	Per Cent Reduction	Chironomidae[1]	Oligochaeta	Miscellaneous[2]
Before treatment						
2	23	88	—	2.3	17	1.7
After treatment						
2	23	57.6	35	0.5	18	1.0
3	8	45.3	49	0.2	24	0.8
8	20	36.8	58	—	—	—
11	25	22	75	—	—	—
13	30	15.9	82	0.07	8	1.0
96	30	0	100	0	30	0.37
288	11	0.55	—	0.3	27	0.1
296	10	0.1	—	0.2	27	0.1
302	10	0.2	—	0.5	24	0
324	10	0	—	0.2	25	0.4
356	10	0	—	0.5	48	0.1
536	20	0.25	—	1.3	34	0.05

[1] Tendipedidae, *Tendipes* sp., and *Pelopus* sp. (identified by C. T. Greene).
[2] Predominantly Diptera, many Heleidae, *Palpomyia* sp. (*Culicoides*)

treatment, when a lower population was observed. However, 96 days after treatment a larger population was indicated than before treatment. *Culicoides* sp. was apparently unharmed by the treatment. From 302 to 536 days after treatment Oligochaeta were as numerous as before treatment of the lake.

To determine how long the chemical remained toxic in the water tests were made daily of top and bottom samples of water from two stations. A water bottle was used to obtain water from the bottom. Pint mason jars were washed in acetone each day to remove all traces of the insecticide before additional water samples were taken. Gnat larvae collected from Clear Lake were used in these tests. Table 2 shows that the water was completely toxic to gnat larvae in 20 hours, 8 days after treatment of the lake. After 8 days a few survived a 20-hour exposure. The 6-hour mortality counts showed an abrupt drop on the twelfth and thirteenth days. Another method of sampling was used to check further on the toxicity of the water on the lake bottom. Water was drawn through a clean rubber hose from the 18-foot level by means of a pump. No difference in mortality of larvae was observed between the two methods of sampling.

TREATMENT OF DETERT RESERVOIR.—Another field test was made to determine whether a lower concentration of TDE would perform satisfactorily. A reservoir on the old Guenoc Ranch near Middletown, in Lake County, appeared to be suitable for conducting a test on Clear Lake gnat larvae. This reservoir, known locally as Detert, was built in 1924, and is located approximately 12 airline miles south of Clear Lake. The reservoir was

Table 2.—Mortality of Clear Lake gnats exposed to samples of water from Lower Blue Lake after treatment with TDE.

Days After Treatment	After Exposure for 6 Hours		After Exposure for 20 Hours		Untreated Check After Exposure for 20 Hours	
	Surface	Bottom	Surface	Bottom	Surface	Bottom
1	17	0	100	100	—	—
2	50	25	100	100	—	—
3	70	65	100	100	—	—
4	61	53	100	100	—	—
5	27	35	100	100	—	—
6	13	35	100	100	0	0
7	10	37	100	100	0	0
8	10	47	100	100	0	0
9	27	22	100	90	0	0
10	22	15	97.5	97.5	28	28
11	37	50	97.5	97.5	0	0
12	17	0.75	90	97.5	28	28
13	0.25	0	85	92.5	5	5

mapped by triangulation, and bottom contour lines were determined by taking 165 depth soundings with a steel tape. Jack L. Dodge, deputy county surveyor, plotted the depth contours and found that the reservoir contained 65 surface acres and 490 acre feet of water. The width of the reservoir ranged from 500 to 1500

feet, and at the time of spraying it was about 3800 feet in length. Water along the shore line was shallow except in the area near the fill, where the depth was 15 feet. The greatest depth was 21 feet, but a large portion was less than 10 feet deep. Aquatic plants were growing in profusion in all shallow areas of the reservoir. Aquatic insects, fish life, and vegetation appeared to be similar to those present in Clear Lake. *Chaoborus* larvae were more numerous in the bottom mud of this reservoir than has usually been found in Clear Lake.

Because the reservoir had to be treated before cold weather, only 15 bottom samples in 2 series were taken prior to treatment. On an average 720 *Chaoborus* larvae per sample were recorded.

The same TDE emulsion used previously was applied to the reservoir on October 15, 1948, at a concentration of 1 part of active ingredient to 75 million parts of water. A small gasoline engine and a rotary gear pump with a single-nozzle spray head and a No. 6 disk were used to spray the chemical over the water. Only 2 quarts of water were added to 5 gallons of the concentrate. The gear pump became plugged and was useless after one-third of the material had been sprayed. The remainder of the insecticide was dripped into the propeller wash as the boat made swaths up and down the reservoir. The coverage of this reservoir with the insecticide was purposely incomplete to determine whether the concentrated insecticide and lake water would mix adequately. Only 10 swaths approximately 100 feet apart and 1400 feet in length were made, less than half the length of the reservoir. Spraying was not done closer to the shore than 200 feet except at two or three places near the earthen fill.

The water temperature at the time of application was 65° F. in the main lake and 74° next to the shore in the weeds. The day was clear, bright, and warm, with an air temperature of 74°. A wind of approximately 2 miles per hour caused ripples on the surface, and the spray mixed readily with the water. No milky mixture formed, as during the test in Lower Blue Lake.

After the treatment bottom samples were taken daily for 3 days and then every other day. Table 3 shows that the average number of *Chaoborus* larvae fluctuated during the first 4 days, but within 7 days the population was reduced 52 per cent. In 15 days the reduction was more than 95 per cent, and in 35 days it was 99.89 per cent. No *Chaoborus* larvae were found 194 days after treatment. Apparently the emulsion was distributed completely throughout the reservoir, since water samples taken 2 days after treatment at the extreme northwest end, which was about 2000 feet from the nearest point of application, were 100 per cent toxic when brought to the laboratory and tested on Clear Lake gnat larvae.

The chironomid population, which averaged 6 per sample of bottom mud

Table 3.—*Chaoborus* larvae (and other aquatic organisms) found in 6-inch square samples of bottom mud before and after treatment of Detert Reservoir with TDE, Reservoir treated October 15, 1948.

Days Before and After Treatment	Number of Samples	*Chaoborus*		Average Number per Sample		
		Average Per Sample	Per Cent Reduction	Chironomidae	Oligochaeta	Culicoides
Before treatment						
1 and 22	15	720	—	6	20	1.5
After treatment						
1	5	530	—	1	17	0
2	8	966	—	1.5	20	0
3	5	472	—	1	20	0
5	10	612	15	0.6	30	0.1
7	10	344	52	0.3	19	0
9	10	288	60	0.8	39	0.2
11	10	121	83	0.4	45	0.4
13	10	86	88	0.7	36	0.1
15	10	35	95	0	44	0
35	25	0.04	99.89	0	39	0.5
194	24	0	100	1.0	23	1.0

before the insecticide was applied, seemed to have been completely eliminated 15 days after the treatment. The Oligochaeta and *Culicoides* populations were not visibly reduced in 35 days of observations.

No dead or affected fish were seen by the writers and others during the entire 35-day period in which this reservoir was under observation. Garth I. Murphy, of the California State Division of Fish and Game, stated that the fish fauna of Detert Reservoir consisted of large-mouth black bass, bluegill sunfish, and green sunfish, which probably would not be affected by the concentration of chemical that was used.

DISCUSSION.—These two tests indicate that *Chaoborus* larvae can be greatly reduced or eliminated in small lakes. The second test shows that a rather poor coverage with the insecticide at a weak concentration will result in adequate mixing and dispersion throughout the water. On the basis of laboratory tests and other information, it is believed that control of the gnat larvae will be more certain if the insecticide is applied in late August or early in September, when water temperatures at night range from 70° to 75° F. During this time 90 to 95 per cent of the larvae in Clear Lake leave the bottom mud. At a water temperature of 65° only 50 per cent were found to leave the mud each night. Under warm conditions a greater number of larvae would therefore be exposed to the treated water during the first few days, when the concentration of the insecticide would be highest.

The concentration of 1 part of TDE to 75 million parts of water probably allows a considerable margin of safety to the fish populations. This concentration will eliminate chironomid larvae, but the test at Lower Blue Lake indicated that the return of these species is rapid. *Chaoborus* larvae furnish perhaps from 10 to 20 per cent of the total diet of the fish in Clear Lake. The elimination of *Chaoborus* will force fish to seek other types of food. If this happens, it may or may not cause any deleterious effect, but in any large-scale spraying, such as on Clear Lake, the possibility of some changes in fish life should be taken into consideration. The benefits to be accrued from gnat control should be carefully weighed against possible ill effects on fish life.

SUMMARY.—Lower Blue Lake (46 surface acres) in Lake County, California, was sprayed on November 7, 1947, with a TDE-xylene emulsion[1] for the control of the Clear Lake gnat, *Chaoborus astictopus* D. & S., the larvae of which inhabit the bottom mud during the daylight hours. The concentration used was 1 part of TDE to 45 million parts of water. The *Chaoborus* larvae were reduced from 88 per 36 inches square to zero within 96 days. In 288 to 536 days the larval population had increased to a maximum of only 0.5 per 6 square inches, even though a good source of reinfestation existed only 800 feet distant. The chironomid larvae were eliminated 13 days after treatment, but a strong recovery was evident in 288 to 356 days. Oligochaeta and *Culicoides* were not reduced in numbers.

To test a lower concentration of the chemical, Detert Reservoir (65 surface acres), in Lake County, was sprayed with the TDE emulsion at the rate of 1 part of insecticide to 75 million parts of water on October 16, 1948. The coverage was purposely incomplete to determine whether the spray and water would mix. In 35 days 99 per cent of the *Chaoborus* larvae were eliminated. No larvae could be found 194 days after treatment. The chemical had mixed throughout the water within 2 days, as was evidenced by the toxicity of water samples. The chironomid population was eliminated but Oligochaeta were not injured.

[1] Emulsifier *Triton X-100*.

LITERATURE CITED

Lindquist, Arthur W., and C. C. Deonier. 1942. Emergence habits of the Clear Lake Gnat. Kans. Ent. Soc. Jour. **15**(4): 109–20.

Lindquist, Arthur W., and C. C. Deonier. 1943. Seasonal abundance and distribution of larvae of the Clear Lake Gnat. Kans. Ent. Soc. Jour. **16**(4): 143–9.

Toxicity of Organic Insecticides to Honeybees: Stomach Poison and Field Tests[1]

NEVIN WEAVER, *Texas Agricultural Experiment Station*

Many destructive insects are controlled with almost equal facility by a number of different insecticides. The farmer growing field crops that are dependent upon insect pollination needs information on the toxicity of insecticides to the honeybee so that he can protect his crop from insect damage and still retain the maximum number of pollinators.

In order to obtain information concerning the effects of organic poisons on honeybees a series of studies was begun in 1948. The toxicity of several insecticides when used as contact poisons has been reported (Weaver 1949). The work herein reported was conducted at College Station, Texas, during 1949 to ascertain the toxicity of benzene hexachloride, DDT, chlordane, and toxaphene to honeybees when used as stomach poisons and when applied to cotton in the field for injurious insect control.

LABORATORY TESTS.—Technical grades of benzene hexachloride, chlordane and toxaphene were dissolved in an emulsible solvent. Technical DDT was almost completely dissolved in benzene and enough emulsible solvent added to complete the solution. Known quantities of these solutions were added to a mixture of 6 parts water, 4 parts honey and 1 part sugar. Bees were taken from the upper (honey) chamber of a colony of naturally mated Italian stock and held over night without food. Each bee was placed in a size 00 gelatin capsule with a small hole in the end and weighed on milligram balances (accurate to 0.2 mgm.). These capsules were placed in the corrugations of pasteboard so that the activities of the bees would not cause them to roll. The poison-containing food solution was shaken vigorously for several minutes in order to insure complete dispersion of the insecticide, and a small drop of this food was placed on a plate glass in front of each bee. After the bees had fed they were reweighed and transferred to individual queen bee shipping cages approximately $25 \times 75 \times 12$ mm. in size. The tare weights of the capsules were then taken. Any bee that regurgitated in the capsule was rejected. Queen candy, a thick paste made by kneading honey with powdered sugar, was placed in one end of the cages to serve as a source of food. The bees poisoned with benzene hexachloride, chlordane and toxaphene, with their checks, were held in a cabinet maintaining a constant temperature of 94° F. and a relative humidity ranging between 66 and 74 per cent. This approximates very closely the temperature and relative humidity in the brood nest (Anderson 1948). Since there was no mortality from DDT at this temperature, the DDT poisoned bees and their checks were placed in another cabinet which maintained a temperature range of 74° to 82° F. and a relative humidity range of 64 to 80 per cent. The dead were counted daily for 3 days. In each series, each insecticide was fed to 10 bees. These series were replicated using various dosages to obtain adequate samples to calculate the toxicity curves. Checks, or bees given a food solution containing the solvent alone, were included in each series.

A minimum of 120 bees was used for establishing each dosage mortality curve. The amount of insecticide consumed was computed on a mgm. insecticide per gm. body weight basis and the bees were grouped as outlined by Bliss (1938). The percentage of mortality within each group was calculated by Abbott's formula, the dosages were converted to logarithms, the percentages of mortality to probits, and the dosage mortality curve was calculated according to the method of Bliss.

RESULTS.—The dosage mortality curves for gamma benzene hexachloride, chlordane, toxaphene and DDT are shown in figure 1. Following poisoning with DDT, 30 per cent of the mortality occurred on the second day, but almost all of the mortality due to the other insecticides occurred on the first day. The visible effects of large amounts of benzene hexachloride was almost immediate. Within a few minutes after ingestion the bees began to run about rapidly and there was evidence of poor muscular control. Some of the bees were moribund or dead within

[1] Technical Contribution No. 1300, Texas Agricultural Experiment Station.

3 hours. At a temperature of 94° F. the median lethal dosages for gamma benzene hexachloride, chlordane and toxaphene were, respectively, .001296, .01249 and .27778 mgm. of insecticide per gm. body weight.

For the first few tests, DDT was dissolved in the same emulsible solvent as the other insecticides and the bees kept in the same cabinet. Under these conditions the dosage necessary to produce mortality was so large that the check bees, fed equal amounts of the solvent alone, died at approximately the same rate as the DDT treated bees. The insecticide was then dissolved in benzene, since it was found that a more concentrated solution could be formed with this solvent, but again there was no appreciable difference in the mortality of the checks and the poisoned bees. Tests were then run in the cooler cabinet, and at a temperature of below 82° F. the median lethal dosage was .2913 mgm. DDT per gm. body weight.

FIELD TESTS AND OBSERVATIONS.—Cages 6×6×36 feet were set up over two rows of cotton in the Brazos Valley. Each cage contained a two frame nucleus with a pound and a half of bees. A pail with small holes in the top was inverted inside the cage as a source of water. Pellets of trapped, bee gathered pollen, either fresh from a pollen trap or desiccated in a drier, were poured into cells of the honeycombs weekly.

All bolls were picked weekly in order to prolong the blooming period of the cotton. In the check and DDT treated cages boll weevils were controlled by hand picking. Measured quantities of insecticidal dust were applied to the cotton in the cages with rotary hand guns at 10 to 30 pounds per acre. A total of 130 pounds per acre of each insecticide was used in eight applications. The nuclei and water cans were removed from the cages while the dusts were being applied.

Dead bees were removed from the cages and recorded daily except Sundays. Half of the bees that were found dead on Mondays, or on days following a rain which prevented a count, were assumed to have died on the previous day. To estimate the initial strengths of the nuclei it was assumed that there are 3500 bees per pound (Nolan, 1932). The percentages of mortality were calculated by Abbott's formula.

RESULTS.—Bees worked inside the cages in an apparently normal manner in spite of the fact that at any time there were more nectar-gathering bees than are normally found on cotton in an equal area near a large apiary. The effect of this over-crowding of bees on the apparent toxicities of the insecticides is not known but it seems likely that mortality was decreased. The tests, however, are believed to give fairly good comparisons between the toxicities of the various insecticides.

The amount of nectar secreted by cotton plants is highly variable, but, except during the heat of the day, there was always some secretion from the flowers. The blossom is subtended by three bracts. There is a nectary at the base of each of the bracts, and others between the bracts at the base of the calyx. These nectaries are well exposed to insecticides and often secrete nectar profusely. The nectaries on the midribs of the leaves secreted no nectar during the tests. There are additional nectaries inside of the fused calyx. Bees are able to reach the nectar in the cup-like calyx by inserting their tongues between the bases of the petals, but since the flower is closed until well after sunrise it is doubtful that this nectar becomes contaminated with insecticides. Before blooming the flower buds with their involuting bracts are known as squares. Nectar usually was secreted by the basal nectaries of the large squares and small bolls, and rarely from fairly large bolls. One cage was moved during the season to an area that had not received insecticidal treatment. Insects had destroyed almost all of the squares on the cotton, and no nectar was secreted until flowering began. Then nectar was secreted by squares and bolls just as profusely in this as in other cages.

Occasionally bees were seen trying to gather pollen from cotton, but they seemed to be unable to form solid pellets on their corbiculae, and usually alighted on a leaf and combed themselves thoroughly before returning to the hive. Pollen adheres to the hairs of bees that come into contact with the anthers while gathering nectar from inside of blossoms. The adhering pollen gives them a white

pollinose appearance when they return to the hive, but they are clean when they again go to the field. Since cotton pollen is rarely seen in the hive, it is probably consumed by the bees without being stored, but the total amount of such pollen is so small in comparison to the amount normally used by a colony that it is doubtful that insecticidal contamination of cotton pollen is a significant factor in adult or larval honeybee mortality. Pollen gathered from other plants growing in or near cotton fields, however, has been found to contain lethal dosages of arsenic (McGregor *et al.* 1947), and this pollen seems to be a major factor in the extensive larval death following applications of arsenical poisons. Larval mortality resulting from the use in the field of organic insecticides has not been observed.

On the days that insecticides were applied, and to some extent on other days, there were a number of bees beating against the tops of the cages. Since the number of bees that were trying to escape from the cages was roughly proportional to the dead found on the following day, it is assumed that the bees trying to escape were suffering from the effects of insecticidal poisoning. However, after about three weeks inside the enclosures, there were a large number of bees beating against the screens every day. Mortality in all cages, including the check, was high, so the bees were replaced. The new bees worked normally for about three weeks and then began beating against the screens. They were, nevertheless, left in the cages for two additional insecticidal applications. During these two tests mortality in the check was so high that, after the second day following dusting, it exceeded the death in all the cages except those treated with chlordane and parathion.

The following insecticides, applied at an average rate of sixteen pounds per acre, were used: (1) 3 per cent gamma benzene hexachloride-5 per cent DDT-40 per cent sulfur, (2) 10 per cent DDT-82 per cent sulfur, (3) 10 per cent chlordane-40 per cent sulfur, and (4) 20 per cent toxaphene-40 per cent sulfur. The average percentages of mortality for the first 3 days following dusting are shown in figure 2. After the third day toxicity from all materials was slight. It can be seen that none of the insecticides tested was highly toxic to the honeybee. Over half of the mortality due to chlordane, the most toxic of the materials tested, occurred following an application of 30 pounds per acre, and death due to this insecticide varied greatly from application to application. The total mortality due to 130 pounds of chlordane used in 8 applications was 25 per cent. DDT was second only to chlordane in toxicity. The mortality for the season, however, was only 9 per cent, and there was little fluctuation in its action from week to week.

In the cages there was no repellent action from any insecticide except the 3 per cent gamma benzene hexachloride-5 per cent DDT-40 per cent sulfur. On the mornings that 3-5-40 was applied no bees left the nucleus until about nine o'clock in the morning. By this time there had always been some wind and a rise in temperature which presumably dissipated the benzene hexachloride to some extent. The repellent action may account for the low mortality due to this material. Unfortunately there was no opportunity to make observations on the repellency of 3-5-40 in open fields of cotton. It is possible that the odor of the insecticide caused the bees to stay inside the nucleus which sat between the rows, but would not prevent the visits of bees flying over a field. In the cages the mortality averaged 0.31 per cent the first day, but after the third day the average mortality was less in this than in the check cage, so that the total death in the two cages was almost exactly equal at the end of the 8 weeks. There was, however, considerable variation in mortality from application to application.

Toxaphene was the most promising of the materials tested. The total mortality at the end of the experiment was 3 per cent, and though this was a little higher than the total mortality due to 3-5-40 there was almost no variation in the action of this insecticide. Almost every day, death was just slightly higher than in the check cage, and the highest average mortality on any day was only 0.15 per cent.

When the cages were constructed it was feared that the bees would work so abnormally in enclosures that a true idea of the comparative toxicities of the insecticides could not be obtained. Since in

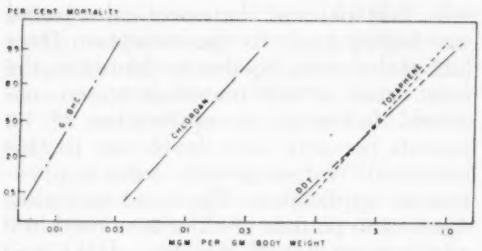

FIG. 1.—Dosage-mortality curves for the toxicity of insecticides as indicated when tested against the honeybee as stomach poisons. DDT treated bees held at below 82° F., other bees at 94° F.

the field calcium arsenate dusted on cotton usually destroys colonies of bees in from a few hours to a few days, another cage was constructed and the cotton inside was dusted with this material. It was applied on two weekly periods at 10 pounds per acre each time, and killed about 70 per cent of the bees. The toxicity of calcium arsenate in open fields is usually higher than this, and it is likely that over-crowding accounted for the low mortality. However, observations on all bees indicated that work in the cages was sufficiently normal to give an indication of the comparative toxicities of the insecticides, so the cage was moved to another area for tests on parathion. Unfortunately insects had almost completely destroyed the squares on this cotton and it was 3 weeks before there was any nectar for the bees to gather. Following three applications of 1 per cent parathion at 10 pounds per acre, the average percentage of mortality on the first day after dusting was 1.78 per cent, on the second day 0.32 per cent, and on succeeding days considerably lower. The total mortality due to 30 pounds of parathion per acre was 10 per cent. These data indicate that parathion may be more toxic to honeybees than any of the other organic materials tested.

FIELD OBSERVATIONS.—It is difficult to make accurate field observations on the toxicity of insecticides to bees except in cases in which there is high mortality. Even when there is a considerable decrease in colony strength over a period of several weeks, extensive observations are necessary to indicate whether the losses are due to insecticides or to natural causes.

In 1946, several visits were made to an apiary in the Lower Rio Grande Valley of Texas, near a field of peppers which had been dusted with DDT. In and near the colonies, and among the pepper plants the bees were perfectly normal in appearance, but about twenty feet from the hives, in the line of flight to the field, was a strip of tall grass which was filled with bees unable to fly or walk normally. Whether they fell into the grass while flying from the hives or from the field could not be ascertained. In spite of the large number of dying bees to be found at any time no decrease in colony strength was apparent.

An apiary in the Brazos Valley was under observation during part of 1949. All the cotton within 2 miles of the apiary was dusted once with 3-5-40 and 5 times with toxaphene without any apparent effects on the bees. One dusting of calcium arsenate with 1 per cent gamma benzene hexachloride killed most of the bees, though the beekeeper saved all but three of the colonies by adding emerging brood and bees.

Two other apiaries in the vicinity of cotton dusted with toxaphene throughout the entire summer were under close ob-

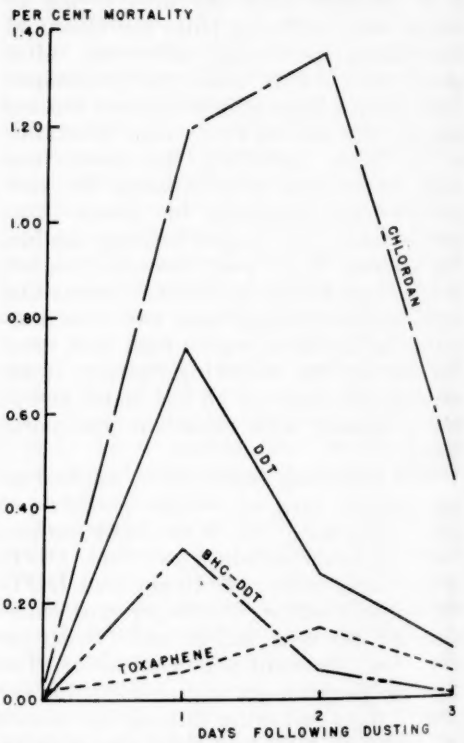

FIG. 2.—Average percentages mortality of honeybees for the first three days following dusting of cotton in large cages.

servation. No deleterious effects of the insecticide was noted. An apiary near Waco was located within a quarter of a mile of a field of Madrid clover which was dusted with 15 pounds per acre of 20 per cent toxaphene. A visit to the apiary the next day revealed no abnormal bees and no decrease in the number of working bees from the number in a nearby, undusted field.

Aside from reports from beekeepers of heavy damage to bees by parathion dusted on vetch, only two cases of severe losses caused by organic insecticides have been reported to this laboratory. In each instance the apiary was very near a field that was dusted with an insecticide containing benzene hexachloride, and in one instance it is known that a fairly strong wind was blowing toward the apiary while the dust was being applied. The susceptibility of bees to contact poisoning by benzene hexachloride, the proximity of the apiaries to the field, and the described actions of the bees, indicate that the extensive mortality was probably due to the contact effects of the insecticide.

SUMMARY AND CONCLUSIONS.—Honeybees were starved, given food containing an emulsion of insecticide, placed in constant temperature and humidity cabinets and observed for 3 days. At 94° F. the median lethal dosages for gamma benzene hexachloride, chlordane and toxaphene were, respectively, .001296, .01249 and .27778 mgm. of insecticide per gm. body weight. At this temperature sufficient concentrations of DDT to cause mortality could not be attained, but at less than 82° F. the MLD was .2913 mgm. of DDT per gm. body weight.

Bees were allowed to work cotton inside of large cages. High mortality resulted when the bees were left inside the cages for more than 3 weeks. Except in one check cage, the cotton in each cage was dusted weekly with varying dosages of an insecticide for 8 weeks. A total of 130 pounds per acre of each insecticide was applied during the test. Dead bees were collected daily except Sundays and the percentages of mortality calculated. The safest of the insecticides tested was 20 per cent toxaphene-40 per cent sulfur. Death on all days was negligible and there was little variation from application to application. Ten per cent DDT-40 per cent sulfur and 10 per cent chlordane-40 per cent sulfur were more toxic, but death was not high from these insecticides. Bees were repelled from the cotton for about 3 hours following applications of 3 per cent gamma benzene hexachloride-5 per cent DDT-40 per cent sulfur, and mortality from this material was slight. Reports from beekeepers, however, indicate that insecticides containing benzene hexachloride may be highly toxic under certain conditions. Preliminary tests indicate that parathion may be more toxic to bees than any of these materials.

None of the organic insecticides tested is as destructive to bees, when used in the field, as is calcium arsenate.

LITERATURE CITED

Anderson, Edwin J. 1948. Hive humidity and its effect upon wintering of bees. JOUR. ECON. ENT. **41**(4): 608–11.

Bliss, C. I. 1938. The determination of the dosage-mortality curve from small numbers. Quart. Jour. Pharmacy and Pharmacology **11**(2): 192–216.

McGregor, S. E., A. B. Caster and Marvin H. Frost, Jr. 1947. Honeybee losses as related to crop dusting with arsenicals. Univ. Ariz. Agr. Expt. Sta. Bul. **114.**

Nolan, W. J. 1932. The development of package-bee colonies. U.S.D.A. Tech. Bul. **309.**

Weaver, Nevin. 1949. The toxicity of certain organic insecticides to honeybees. JOUR. ECON. ENT. **42**(6): 973–5.

HERBERT SPENCER BARBER

Herbert Spencer Barber, a member of this Association since its reorganization in 1908 and of the Bureau of Entomology since 1902, died on June 1, 1950, at his home in Washington, D. C.

An obituary notice will be published as soon as it is made available.

Absorption and Translocation of Insecticides Through the Root Systems of Plants[1]

ORDWAY STARNES, *New Jersey Agr. Expt. Station,*[2] *New Brunswick*

The effectiveness of several recently developed synthetic organic compounds against agricultural pests has resulted in their greatly expanded use. Several complications have arisen from this expanded use, important among which is the possibility that the insecticide may be absorbed and translocated to edible parts of the plant, rendering these edible parts undesirable in flavor or contaminated by the presence of a toxicant. This possibility was suggested from reports that varying degrees of undesirable flavors had been imparted to potatoes grown in soil to which one of these insecticides, benzene hexachloride, had been added. Such reports gave impetus to the following investigation which consisted of: (1) the growing of several species of plants in the field and in the greenhouse in soil containing concentrations of insecticides. The concentration of insecticide used was limited to the extent that information obtained might be significant in evaluating the insecticide for practical control. (2) Observing the effects of each insecticide on plant growth and yield. (3) Infesting plants with suitable insect species to obtain a qualitative indication of the presence of a toxicant. (4) Performing such bioassay tests as would permit a quantitative approximation of the presence of a toxicant. (5) When the presence of a toxicant was indicated by biological tests, chemical analyses were made when time and facilities permitted.

Previous studies were conducted on the absorption and translocation of selenium and is reviewed by Moxon & Rhian (1943). Fulton & Mason (1937) found that derris constituents were translocated in bean plants and Questel & Connin (1947) grew corn in concentrations of parathion, the leaves and stalks of which were lethal to larvae of the European corn borer. During the course of these investigations, Grainger & Leiby (1949) reported that plants grown in soil containing concentrations of parathion, produced potato foliage lethal to the aphid *Microsiphum sanbornii*, Ashm., bean foliage lethal to larvae of the Mexican bean beetle, *Epilachna varivestis*, Muls.; and squash foliage lethal to the melon aphid, *Aphis gossypii*, Glov. Undesirable flavors attributed to the growth of plants in soil containing concentrations of insecticides or to the application of these to plants have been reported with increasing frequency in recent months.

PROCEDURE.—The amounts of insecticide applied to soil in the greenhouse were based on the ratio that 1 microgram of insecticide admixed with 1 gram of air dried soil resulted in a concentration of 1 part per million of insecticide. And all concentrations have been converted into pounds applied per acre in order that greenhouse and field results might be compared. This calculation was accomplished by using the generally accepted weight of 6 inches of average soil over the surface area of an acre as equal to 2 million pounds. Soil pots used in the greenhouse were 8 inches in diameter and 6 inches deep. Insecticides were admixed with air dried soil prior to planting.

Several cultures of insects were maintained for infesting greenhouse grown plants and plant products. Bioassay tests were conducted by two methods to quantitatively approximate the amount of toxicant contained in plant tissue. The first methods consisted of the comparison of two dosage-mortality curves, the first being a curve obtained by diluting macerated plant tissue each milliliter of which represented a known amount of treated plant sample, with distilled water, and the second a curve obtained by diluting standard solutions of insecticides to obtain a 1 per cent acetone suspension with distilled water containing the amount of mascerated tissue of untreated plants as was determined to produce an LD50 when treated plant tissue was used. Treated and untreated plant tissue was macerated in a waring blendor and diluted with distilled water until sufficiently fluid to pipette. Aliquots of this macerated tissue,

Eastern Branch Program, 1949.

[1] Paper of the Journal Series, New Jersey Agricultural Experiment Station, Rutgers University, the State University of New Jersey, Department of Entomology.

[2] Unpublished thesis.

representing known amounts of plant sample were diluted with distilled water to give concentrations of 1 to 10 grams of plant sample per 100 milliliters. This aqueous suspension of plant material was placed in 100 ml. beakers and 20, fourth instar, larvae of *Aëdes aegypti* (L.) were added. The beakers were covered and mortality recorded at 24 and 48 hour intervals. Additional dilutions were made when necessary in order to determine the concentration of treated plant material required to produce an LD50. Tests were performed in duplicate and repeated at least once. The plotted results constituted curve (a). When the untreated plant material, at an equal concentration, caused significant mortality the treated plant tissue was not deemed to contain sufficient toxicant for significant results by this method. When the untreated plant material caused no mortality the test was deemed valid and a second dosage-mortality curve was obtained by the addition of insecticides to suspensions of untreated plant tissue. This was necessary as it was determined that the activity of insecticides in the presence of plant materials was markedly suppressed. Tests were duplicated and repeated at least once. The amount of toxicant in the plant material was then calculated by dividing 100 by the concentration of treated plant material required to produce an LD50 and multiplying this product by the number of micrograms of insecticide per ml. required to produce an LD50 in the presence of untreated plant material.

The second method used was similar to that described by Nolan & Wilcoxon[1] and, like the first method, based upon the comparison of two dosage-mortality curves: (a) a curve obtained by diluting the benzene extracts of treated plant tissue, each milliliter of which represented a known amount of plant material, and (b) a curve obtained by diluting a standard solution of insecticide containing the extracts of untreated plant tissue. Aliquots of benzene extracts, representing grams of plant sample, were pipetted into 100 ml. beakers to give concentrations of from 1 to 10 grams of plant material. Benzene was then evaporated under a fan at room temperature, the dry residue suspended with 0.5 ml. of acetone and to this was added 49.5 mls. distilled water containing 20 four instar larvae of *Aëdes aegypti* (L.). Beakers were covered and mortality observed at 24 and 40 hours. Results were plotted and when necessary additional concentrations were examined. Tests were performed in duplicate and repeated at least once, and the results constituted curve (a), the grams of treated plant material per 50 ml. required for an LD50. Curve (b) was obtained by adding to aliquots of the benzene extracts of untreated plant material, which yielded the same concentration expressed in grams of untreated plant tissue per milliliter of benzene, standard solutions of insecticides. These solutions were examined in the same manner as were the extracts of treated plant tissue leading to an LD50 value for the standard expressed in micrograms of insecticide per 50 ml. The fraction LD50 of standard solution divided by the LD50 of treated sample gave the concentration of toxicant in part per million. Checks to determine whether the activity of insecticides was suppressed in the presence of benzene extracts of untreated plant tissue were conducted. Checks in which *Aëdes* larvae were added to 1 per cent acetone solutions, acetone suspensions of the residue form evaporated benzene and water were conducted throughout these tests.

Chemical analyses of plant tissue was limited to those plants grown in soil containing concentrations of parathion which exhibited biological toxicity. The method used was that described by Averell & Norris (1948). Although biological activity was encountered in the examination of plant tissue grown in soil containing benzene hexachloride, chemical determinations were not made due to a lack of facilities and the questionable accuracy of the method in determining benzene hexachloride in the presence of plant tissue.

The available field soil, a sassafras sandy loam, was divided into plots 25 by 35 feet replicated three times and plowed and harrowed. The insecticides were diluted to concentrations which, when applied at the rate of 200 lbs. per acre with a grain drill, deposited the desired amount of insecticide. Following the application of insecticides the soil was disced and planted. Potatoes were planted in each of the three replicated plots while the re-

[1] Unpublished data.

Table 1.—Insecticides applied in field to soil in which beans,[1] beets,[2] corn,[3] potatoes,[4] and tomatoes[5] were grown.

INSECTICIDE	AMOUNT OF ACTIVE INGREDIENT APPLIED PER ACRE
γ-Benzene hexachloride, g.i.	0.125, 0.25, 0.5, 1.0
Chlordane Tech.	2, 4, 8, 16
Parathion, 25% wettable powder	5, 10, 20
Toxaphene, 25%	25, 50

[1] Burpee bush lima.
[2] Detroit dark red.
[3] Marcross 6.13.
[4] Katahdin.
[5] Henderson's Marglobe.

maining crops were planted only in duplicate plots.

Observations made throughout the growing season did not indicate that the various treatments caused significant differences in plant growth. Yield data were taken only on potatoes and it was found that on the plots receiving 50 pounds per acre of toxaphene the yield was significantly reduced.

Counts of the major insects infesting the plants were made throughout the season at weekly intervals but significant differences, which could be correlated with the treatments applied, were not observed.

Bioassay tests were performed at intervals using the entire plant above ground of each crop. Bioassay tests of beans at canning stage, beet roots, sweet corn at proper maturity for quality, potato tubers and ripe tomato fruits were performed a minimum of three times. These bioassay tests did not indicate the presence of a toxicant in either the plants or plant products.

GREENHOUSE TESTS.—Greenhouse tests were conducted concurrently with field experiments. Initial tests consisted of the growing of beans, beets, corn, potatoes, and tomatoes in soil containing relatively low concentrations of insecticide as indicated in table 2.

All tests were replicated a minimum of three times. Tests in which beets and corn were grown in soil containing concentrations of *Ryania* were replicated eight and 10 times respectively.

Observations were made on the germination of beans, beets, corn and potatoes but significant differences were not determined. Beans were infested with larvae and adults of the Mexican bean beetle, *Epilachna varivestis*, Muls., beets and

Table 2.—Plants grown in potted soil containing insecticides.

PLANTS	CONCENTRATION IN LBS./A. (LBS./2,000,000 LBS.)		
	Synthetic Organics[1]	Quassin	Ryania
Beans	5	50	25, 50
Beets	5	50	25, 50
Corn	5	50	25, 50
Potatoes	5	50	25, 50
Tomatoes	5	50	25, 50

[1] Based on active γ-benzene hexachloride, chlordane, tech., parathion 25% W.P., toxaphene 25%.

corn with larvae of the European corn borer, *Pyrausta nubilalis* Hub., and potatoes and tomatoes with the potato aphid, *Illinoia solanifolii*, Ashm. The insects were able to develop normally on the plants and the mortality observed was not significantly different from that observed on the checks. Bioassay of the tissue of the entire plants above ground and of beet roots, potato tubers, and tomato fruits did not indicate the presence of a toxicant.

Failure to obtain indications of translocation throughout the above reported tests suggested the investigation of plants grown in soil containing higher concentrations of insecticides. Accordingly potatoes were planted to soil containing higher concentrations of gamma isomer benzene hexachloride[1] and parathion[2] as indicated in table 3, under greenhouse conditions.

A significant difference in the rate of sprouting of the tuber was observed as well as a reduction in growth which persisted until maturity. The amount of retardation in sprouting was directly proportional to the amount of insecticide applied.

The plants were infested by caging the aphid, *Macrosiphum rosae*, L., on terminal twigs, on lateral basal leaves and on lateral mid-plant leaves. These tests were conducted at intervals throughout the growth of the plant. The aphids were able to develop normally and establish themselves on any part of plants grown in soil containing the highest concentration of insecticides investigated. Several replicates were also infested with an uncontrolled population of aphids and the degree of that infestation determined at inter-

[1] Experimental sample of pure gamma isomer, California Spray-Chemical Co.
[2] Experimental sample containing 99.6% parathion, American Cyanamid Co.

Table 3.—Comparative rates of sprouting and growth of Katahdin variety potatoes grown in soil containing concentrations of insecticides in days after planting.[1]

Treatment	Pounds per Acre	28 Days		64 Days			Per Cent Reduction in Ht. Over Check at 64 Days
		Plants	Av. Ht. in cm.	Plants	Av. Ht. in cm.	Blossom Clusters	
BHC, g.i.	10	18	6.3	38	111.4	17	34.96
	20	9	5.1	40	43.9	2	74.37
	40	6	5.0	29	33.5	3	80.44
Parathion	25	21	5.5	45	117.9	14	32.34
	50	17	7.6	36	96.2	11	43.84
	100	14	8.1	39	103.6	9	39.52
Check		31	8.8	44	171.3	34	0.0

[1] Based on 10 replicates each pot containing 3 seed pieces.

vals. In all treatments there was a significant reduction in the numbers of aphids infesting plants growing in treated soil and the reduction could be correlated with the amounts of insecticides applied. Three of the replicates were then isolated and infested with uncontrolled larvae of the European corn borer, *Pyrausta nubilalis* Hub., and after 14 days a reduction in survival was observed on the plants grown in parathion treated soil. A significant reduction was observed in the survival of larvae feeding on plants grown in soil treated with benzene hexachloride also, but not in accordance with the concentration applied.

After harvest several tubers were caged separately, the skin cut away and a small vial pushed into the flesh. Through this vial the tubers were infested with newly hatched larvae of the tuber worm, *Gnorimoschema operculella* Zeller, and observations made on the number which developed to form pupae. It was found that only 8 per cent of the larvae which were placed on tubers grown in soil containing 10 pounds per acre of benzene hexachloride developed to form pupae while all the larvae died within a few days when placed on tubers grown in the soil containing 20 and 40 pounds per acre. Larvae were able to develop on tubers grown in each concentration of parathion and a slightly greater percentage of those placed on tubers grown in soil containing 100 pounds per acre formed pupae than did on the untreated checks.

Preliminary bioassay tests of tissue of the entire potato plants above ground indicated high toxicity to *Aëdes* larvae, and suggested a comparison of the two available methods of bioassay which is reported in table 4.

Results of this and many similar tests indicated that either method of bioassay is sufficiently accurate to determine a toxicant under these conditions in the presence of potato plant tissue. Additional bioassay tests of plants, tubers and soil were performed at harvest time or 114 days after planting. Chemical analysis of plants, tubers and of the soil in which they were grown were performed in the case of the parathion treatments. These data are reported in tables 5 and 6.

These results were obtained using the benzene extraction method and each calculation is based upon the LD50 value representing the plotted results of duplicated tests using approximately 600 larvae in each test. Results obtained by the aqueous extraction method were not significantly different.

In all chemical analyses, the per cent

Table 4.—Comparative toxicity calculated in ppm to fourth instar *Aëdes* larvae of aqueous suspensions and benzene extracts of potato plants 45 days after planting in potted soil containing insecsecticides.[1]

Treatment	Lbs./ Acre	Aqueous Suspension	Benzene Extracts
γ-benzene hexachloride	10	1.47	1.48
	20	2.63	2.00
	40	3.68	7.38
Parathion	25	0.14	0.19
	50	0.82	0.38
	100	1.25	0.62

[1] Each calculation based upon LD50 value representing the plotted results of a minimum of duplicated tests using approximately 600 larvae in each test. Check extracts were not toxic at the highest concentration tested.

Table 5.—Summarized results of bioassay test of potted soil containing γ-benzene hexachloride and of potatoes grown therein at harvest time.

Pounds per Acre	Toxicant Determined in p.p.m.		
	Soil	Plant	Tubers
10	2.03	1.96	1.13
20	3.94	3.09	1.14
40	7.14	7.37	2.09

Table 6.—Summarized results of bioassays and chemical analyses of potted soil containing parathion and of potato plants and tubers grown therein at harvest time or 112 days after planting.

Pounds per Acre	Soil		Plant		Tubers	
	Chemically	Bioassay	Chemically	Bioassay	Chemically	Bioassay
25	5.32	3.20	0.11	0.064	0.17	0.15
50	12.13	9.10	0.43	0.107	0.20	0.16
100	21.33	11.00	0.54	0.172	0.22	0.17

transmittance readings for the blanks were subtracted from the treated as well as from check samples. The benzene extraction method was used for bioassays and each calculation based upon the plotted results of duplicated tests using approximately 600 larvae in each. Results obtained by the aqueous extraction method were not significantly different in the case of tubers and plants. Soil was not assayed biologically by the aqueous method.

SUMMARY.—Five vegetable crops were grown in the greenhouse and field in soil containing concentrations of insecticides. Observations were made to determine whether the germination, growth and yield of plants were affected whenever possible. The plants were infested with suitable insect species as a qualitative indication of the presence of a toxicant in the plant tissue. Two methods of assaying plant tissue biologically with the aid of *Aëdes* larvae were compared and both found to be sufficiently sensitive to yield a quantitative indication of the presence of a toxicant in the presence of plant tissue.

It was determined that when potatoes were grown in soil containing 10 pounds per acre of the gamma isomer of benzene hexachloride that the rate of sprouting and growth was retarded and that proportionally greater retardation was observed at higher concentrations. Aqueous suspensions and benzene extracts of the potato foliage and tubers were highly toxic to *Aëdes* larva. The presence of a toxicant was also indicated when these tubers were infested with larva of the potato tuber worm. Bioassay tests also indicated that a large amount of toxicant persists in this soil at harvest time.

Bioassay tests of potatoes, grown in soil containing 25 pounds of parathion per acre, indicated the presence of a toxicant. Chemical analyses indicated that the plant above ground, the tubers and the soil at harvest time contained appreciable amounts of a material which upon analyses indicated the presence of parathion.

LITERATURE CITED

Averell, P. R. and M. V. Norris. 1948. Estimation of small amounts of 0,0-diethyl 0,p-nitrophenyl thi phosphate. Analytical Chemistry **XX**(8), 753.

Fulton, R A., and H. C. Mason. 1937. The translocation of derris constituents in bean plants. Jour. Agr. Res. **LV**(12), 903–7.

Grainger, M. M. and R. W. Leiby. 1949. How plants absorb parathion. Agricultural Chemicals **IV**(2), 34–5.

Moxon A. L., and M. Rhian. 1943. Selenium poisoning. Physiological Review. **XXIII,** 305.

Questal, D. D., and R. V. Connin. 1947. A chemical treatment of soil which produces plant tissues lethal to European corn borer. JOUR. ECON. ENT. **40**(6): 914.

NINTH INTERNATIONAL CONGRESS OF ENTOMOLOGY, AMSTERDAM, AUGUST 17–24, 1951

Travel arrangements for the American delegation will be handled by The Bankers and Merchants Travel Service, 511 Fifth Avenue, New York 17, N. Y., in conjunction with Dr. J. C. Bradley, Cornell University, Ithaca, N. Y.

Residual Toxicity of Chemicals for Black Widow Spider Control[1]

DEANE P. FURMAN and HASIP KURTPINAR,[2] *Division of Entomology and Parasitology, University of California*

Latrodectus mactans (Fabr.), the black widow spider, is a widespread and much dreaded arthropod whose ability to survive and reproduce in the most unexpected places both in and around the home as well as in the field make it a most ubiquitous pest, only imperfectly amenable to control methods. Most insecticide sprays moreover have been quite ineffective in controlling black widows even when actual contact was made. Others which were moderately effective, such as creosote have disadvantages which preclude their application around the home.

Among recent reports that of Vargas & Colorado (1944) is of interest since it seemingly adds DDT to the list of ineffective arachnicides. In their experiments they placed specimens of *Latrodectus mactans* in dishes on a layer of commercial 10 per cent DDT dust and on a filter paper impregnated with a 20 per cent solution of DDT. No kill was obtained during the exposure period of 6 days.

It seems probable that the DDT used in these experiments was defective, however, since they also obtained no kill of *Blatella germanica* when exposed in the same manner as the black widow spiders. On the other hand Van Riper 1946, stated that a 10 per cent solution of DDT in kerosene sprayed on the web of the black widow killed the spider in the web and continued to kill any other spiders placed in the web for some time. Several semi-popular articles also have appeared recently concerning the effects of various insecticides against black widows. Of these benzene hexachloride has probably received the most attention and also the most favorable comments.

The present experiments were conducted to determine the relative efficiency of a number of the newer insecticides in controlling the black widow spider, *Latrodectus mactans*. The scope of the work includes laboratory contact and residual spray tests as well as field tests of the most promising materials.

MATERIALS AND METHODS.—All laboratory work with black widow spiders is subject to the limitations imposed by the cannibalistic, solitary habits of the spiders. This precludes the use of more than one individual per test and necessitates many replications in order to obtain data that are at all conclusive.

The black widow spiders used in control experiments were mature, field collected females maintained individually in the laboratory on a housefly diet. Screening tests employing various insecticides were conducted by spraying 1 cc. of the material in aqueous suspension or emulsion, as indicated, over each spider in a shallow dish provided with a layer of filter paper to absorb excess moisture. The spray was applied uniformily in fine droplet form by a small electric sprayer, and, immediately following treatment, the spiders were transferred to individual clean containers containing absorbent paper. Five spiders were sprayed individually with water as a control for each screening test series.

On the basis of the screening tests those materials most toxic to the spiders were tested for their residual effects in the laboratory. For this purpose small collapsible wooden boxes were constructed having a total inside surface area of 1 square foot. In treating each box it was opened out to a horizontal position and sprayed with the desired amount of insecticide in a volume of 12.6 cc. liquid. This volume was selected as the maximum that could be applied to 1 square foot of surface without risking run off of fluid.

In all residual deposit tests, except where otherwise indicated the work was carried out at room temperature. This usually varied within a range of 16 to 24° C. with an occasional rise to approximately 33° C. The boxes were closed only while actually exposing spiders; the remainder of the time they were opened as a flat, vertical surface in the laboratory. Each spider was exposed in a treated box for 24 hours after which it was placed in a

[1] The able assistance of Mr. George Rohrbacher in laboratory and field work is gratefully acknowledged.

[2] Dr. Kurtpinar is now at Veteriner Umum Mudurlugu, Ankara, Turkey.

clean glass container and supplied with its normal laboratory diet. Mortality was observed over a five day period following treatment.

Field tests were conducted at the University of California airfield near Davis during the months from September through December. The first two months were quite warm with a mean temperature of 22° C. and 16° C. respectively as measured by the Davis weather station. November and particularly December were colder, with mean temperatures of 12.5° C. and 7.5° C. through December 13. This was reflected in decreased activity and reproduction of the spiders as the season progressed.

Three hangars were selected for spraying, with a fourth maintained untreated as a control. All hangars were found moderately to heavily infested in September with from 20 to 40 black widows per building in the areas easily accessible for inspection. The hangars were constructed of corrugated sheet metal, with floors of concrete. Spiders were numerous along wall beams and at the junction of floors and walls, where protected retreats were formed by the corrugated sheet metal. It should be noted that the maximum temperature reached on sunny days was appreciably warmer in the hangars than in shaded areas outdoors. Also, the minimum temperatures reached were not as low as those outdoors.

In spraying the structures a 50 gallon sprayer was used operating at 200 pounds pressure. It was considered unnecessary to spray the entire building so treatment was limited to the junction of wall and floor, along all wall beams, and the junction of ceiling and wall. These areas were wet with the spray but not to the point of appreciable run off.

It was found that approximately 7 gallons of spray were necessary to treat a hangar with a floor area of 4080 square feet and walls approximately 14 feet high.

Following treatment and at weekly intervals thereafter the spider webs in both the treated and untreated hangars were removed up to a level of 4 feet. At these times the hangars were examined both for live spiders and for webs in the check areas. One of the main reasons the field tests were carried out at the airport was that the black widow infestation in this area was heavy enough so that during the seasons of activity almost every suitable site harbored the spider, thus conditions were satisfactory for determining the degree of protection from reinfestation afforded by a residual deposit of toxicant.

Sprays were made up from the following stock materials: 50 per cent wettable powders of DDT, dichlorodiphenyl dichloroethane, methoxychlor and technical benzene hexachloride (of 12 per cent gamma isomer content), 40 per cent wettable toxaphene, 25 per cent wettable lindane, and 47 per cent chlordane emulsion concentrate. In addition aldrin was prepared as a suspension by first dissolving the compound in a small volume of acetone then precipitating it in water.

RESULTS.—In the screening tests an arbitrary concentration of 0.25 per cent of the compound in question was selected as the basis for comparison in most instances. However since the most active ingredient of the 0.25 per cent benzene hexachloride used consists of 0.03 per cent of the gamma isomer, it was considered advisable to test lindane of 0.03 per cent gamma concentration for comparison. Also in testing aldrin, information from the manufacturer indicated that its toxicity would be in the range of lindane, so a comparable concentration was used.

The results of the screening tests are given in table 1, with five of the eight preparations giving 100 per cent mortality. The methoxychlor was eliminated from residual spray tests on the basis of the results shown in this table.

Table 1.—Screening tests against *Latrodectus mactans*.

MATERIAL[1]	PER CENT ACTIVE INGREDIENT	NUMBER SPIDERS	PER CENT MORTALITY
Technical Benzene Hexachloride	0.25 (0.03γ)	13	100
Lindane	0.03	10	100
Aldrin	0.03	10	100
DDT	0.25	15	100
Dichlorodiphenyl dichloroethane	0.25	10	80
Chlordane	0.25	13	100
Methoxychlor	0.25	5	40
Toxaphene	0.25	5	60

[1] All materials applied as aqueous suspensions except chlordane which was an emulsion. A quantity of 1 cc. was sprayed over each spider.

In table 2 are given the results of the residual deposit tests conducted in the laboratory. DDT at the rate of 150 mg. per square foot of surface gave the best results with a lethal action lasting over 112 days. This deposit is the rough equivalent of that obtained by spraying a wall until wet with a suspension containing 20 pounds of 50 per cent wettable DDT per 100 gallons of water.

On two occasions during the period of observation it was found that a 24-hour exposure to the DDT treated box did not kill spiders, although at later periods it did. This type of observation was also noted with some of the other materials as seen in table 2. Undoubtedly some of this variation in results was due to individual differences in hardiness, and behavior patterns, *i.e.* some spiders had a minimal contact with the box surface as they spun webs immediately. Furthermore, the prevailing temperature at the time of the experiments varied somewhat, and, as will be shown later, temperature changes affect the toxicity of some residual deposits.

Effective residual deposits may be considered to have resulted from the first five formulations listed on table 2—all giving kills up to 8 weeks or more. The second group of five formulations must be considered as ranging from relatively ineffective to completely ineffective.

However, after a lindane-treated box seemed to have lost its residual toxicity, it was placed in a warm temperature cabinet for short periods of 1 to 2 days. It was found that the toxicity to spiders was regained, presumably from the fumigant action resulting from more rapid volatilization of the lindane remaining in or on the wood.

To clarify this point two additional test boxes were treated with 18 mgm. of lindane per square foot and maintained respectively at temperatures of 5° and 33° C. The results of these tests are given under the last two formulations listed on table 2. When maintained at 5° C. the residual toxicity was evident for 72 days, or over twice as long as manifested when exposed to a temperature of 33° C. The results at the latter temperature are equivalent to those obtained in the earlier test at room temperature. The increased residual effectiveness of lindane at low temperatures is further emphasized by the fact that the same duration of effectiveness was obtained with 18 mgm. lindane per square foot at 5° C. as with 150 mgm. lindane per square foot at room temperature (16 to 33° C.).

These data are in accordance with what one would expect inasmuch as the rapidity of vaporization of lindane varies with the temperature.

It is obvious then that a surface treated with a small amount of a material such as lindane is dangerous to spiders for an indefinite period of time, depending upon the temperature. This general type of observation is not new, of course, and may be considered to apply to other types

Table 2.—Laboratory tests for comparative residual toxicity of some chlorinated hydrocarbon materials to *Latrodectus mactans*.[1]

Formulation	Deposit in Mgm. per Sq. Ft.	Mortality of Spiders (+=Kill, −=Survival) Following a 24 Hour Exposure — Weeks After Treatment of Exposure Surface																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
DDT	150	+	+	+	+	+	+	+	+	−	+	+	+	+	−	+	+	
Lindane	150	+	+	+	+	+	+	+	+	+	+	−	−	−				
Benzene hexachloride (Tech.)	300 (36γ)	+	+	+	+	+	+	+	+	+	−	+	−	−				
Benzene hexachloride (Tech.)	150 (18γ)	+	+	+	+	+	−	+	+	−	−							
Chlordane	150	+	+	+	+	−	+	+	+	−	−							
Lindane	18	+	+	+	+	−	−											
Aldrin	150	+	+	−	+	−	−											
Chlordane	126	+	+	−	−													
Dichloridiphenyl dichloroethane	150	+	+	−	−													
Toxaphene	150	−	−															
Lindane 5° C.	18	+	+	+	+	+	+	+	+	+	+	−	−					
Lindane 33° C.	18	+	+	+	+	−	−											

[1] All tests conducted at room temperature except where otherwise noted.

of residual deposits to a greater or lesser extent depending upon the volatility of the toxicant used.

In the field tests described above, hangar No. 1 was sprayed September 20, 1949, with a suspension of 25 pounds of 24 per cent lindane to 100 gallons of water, which was applied at a rate to deposit approximately 75 mg. lindane per square foot of treated surface. On the same day hangar No. 2 was sprayed with a suspension of 6.25 pounds of 24 per cent lindane to 100 gallons of water, and applied at a rate to deposit approximately 18 mgm. lindane per square foot. An additional hangar was treated on November 1 with a suspension of 16 pounds of 50 per cent wettable DDT to 100 gallons of water. This was applied at a rate to deposit approximately 100 mgms. DDT per square foot of treated surface.

The results of these applications are summarized in table 3. Actual numbers of live spiders counted at each check are not included since they would be of little significance; the spiders were usually able to retreat when disturbed to sites where they would be overlooked on a normal check. Therefore, counts varied from nine to over 30 in the control hanger during the first 2 months. Ample evidence of their activity was available, however, in the number of new webs constructed following the weekly removal of webbing. During the first week in November the spider count and activity dropped markedly in the control hangar. This may have been due to contamination since the hangar was used for storage of bagged insecticides and equipment for airplane dusting of crops. Although there is a normal decrease in activity and numbers of the black widow spider at this season, the sudden drop in population of this one hangar was not paralled by a corresponding decrease in the spider population of neighboring structures. However, a light infestation of the control hangar was again evident within two weeks.

It should be noted that in every case where new webs were found in treated hangars, either spiders were found dead in or around the webs, or had apparently deserted them, since the webs were not reconstructed following removal.

The data are interpreted as showing that a lindane deposit as low as 18 mg. per square foot of surface killed all black widow spiders present and prevented reinfestation for a period of over 10 weeks. DDT at a rate of 100 mg. per square foot of surface produced identical results, but the period of observation was limited to slightly over one month. Based upon results of the laboratory tests one would expect DDT at this rate to have displayed a longer residual action than lindane had the observation period been more extended.

It should be remembered that the field tests were conducted in the fall of the year and that residual effectiveness would doubtless be greater at this season than during the hot summer months.

The field experiments were terminated in December, 1949, because conditions of potential active reinfestation had decreased to a point where they could not be used to provide a reliable index of the protective action due to residual deposits.

Table 3.—Field tests on residual deposit control of *Latrodectus mactans*.

	Deposit of Compound per Square Foot of Surface (Approximate)			
	75 mg. Lindane	18 mg. Lindane	100 mg. DDT	Control
Date	Spider Incidence[1]			
Sept. 20	+ (treated)	+ (treated)		+
27	−	−		+
Oct. 4	±	−		+
11	±	±		+
18	−	−		+
25	±	±		+
Nov. 1	−	−	+ (treated)	+
8	−	−	−	−
15	−	−	−	+
22	−	−	−	+
28	−	−	−	+
Dec. 6	− (1 egg sac)	−	−	+

[1] + = liver spiders present.
± = no liver spiders but fresh webs present.
− = no live spiders or webs present.

Summary.—Laboratory screening and residual deposit spray tests as well as residual spray field tests were made for control of the black widow spider, *Latrodectus mactans*. In screening tests the methoxychlor was eliminated as being relatively ineffective. In residual tests, toxaphene, dichlorodiphenyl dichloroethane, and aldrin were found to be relatively ineffective. Lindane, technical benzene hexachloride, and chlordane were relatively effective, but not as persistent as DDT which was effective in laboratory tests for over 16 weeks when applied at the rate of 150 mgm. per square foot of surface.

In field tests lindane at 18 mgm. and DDT at 100 mgm. per square foot of surface provided effective control and protection from reinfestation for over 12 weeks and 6 weeks respectively, when the experiments were terminated.

LITERATURE CITED

Van Riper, W. 1946. DDT and the black widow spider. Science 104(2692): 111.
Vargas, L., and Iris R. Colorado. 1944. Acción del DDT sobre algunos atrópodos domésticos. Rev. Soc. Mex. Hist. Nat. 5(3–4): 229–35.

Control of Adult Mosquitoes in Alaska with Aerial Sprays[1]

F. S. BLANTON, *Lt. Col., Medical Service Corps, U. S. Army,* B. V. TRAVIS,[2] NELSON SMITH, and C. N. HUSMAN, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[3]

In the summer of 1949 tests on the control of adult mosquitoes in Alaska were conducted in forested subarctic areas near Fairbanks, and on treeless tundra above the Arctic Circle. The tests were made (1) to determine whether mosquitoes would fly from surrounding unsprayed areas into plots 16 to 100 square miles in size in sufficient numbers to be annoying, and (2) to test the effectiveness of several DDT formulations applied at various dosages.

Four large areas—one each at Eielsen Field, Clear, Oumalik, and Umiat—and 14 small plots were sprayed from the air. The total area covered was 412 square miles, or 263,680 acres.

MATERIALS AND METHODS.—The test plots were sprayed with two C-47 airplanes having special spray equipment designed by Husman (1949) and built by the Alaskan Air Command. The formulations used were an airplane spray containing 20 per cent of DDT, 20 per cent of fuel oil, and 60 per cent of an aromatic hydrocarbon solvent;[4] the 20 per cent spray with 1 per cent of a polyglyceride of a glyptal resin[5] added; an emulsifiable concentrate containing 20 per cent of DDT, 10 per cent of monoisooctyl phenyl polyethylene glycol ether,[6] and 70 per cent of a compound composed chiefly of methylated naphthalenes;[7] or the airplane spray diluted to 5 per cent with No. 2 fuel oil. Unless otherwise designated, the plots were sprayed with the 20 per cent DDT airplane spray at a dosage of 0.1 pound of DDT per acre.

The sprays were applied at swath intervals of 800 feet, and cross-wind. The flight lines on all test plots were marked with smoke grenades, except at Umiat and Oumalik, where the pilot flew the plots entirely by marked maps. The swaths were flown both by means of a compass after the plots were oriented on the markers and by the use of maps on which the flight lines had been drawn previously. With one exception at Eielsen Field, all sprays were applied at night. Wind velocities varied from less than 1 mile per hour to occasional gusts up to 6 miles per hour.

Mosquito populations were determined before and after spraying by landing-rate counts at a number of selected stations within the sprayed area, and whenever possible outside the sprayed area. In all areas except Umiat, observers stood still for 3 minutes and then counted all the mosquitoes landing on the front of their trousers, from waist to cuff, within 1 minute. At Umiat the mosquitoes were so numerous that the numbers on the trousers were only estimated. It was possible, however, to count the mosquitoes landing on the back of a woolen glove. The same observer could not make all the

[1] This work was conducted under funds allotted by the National Military Establishment to the Bureau of Entomology and Plant Quarantine.
[2] Now with Cornell University.
[3] The writers are greatly indebted to other members of the Alaska Insect Project, including Capt. Kermet H. Applewhite, U. S. Army; C. M. Gjullin and Hansell Cross U. S. Bureau of Entomology and Plant Quarantine; Lt. Col. W. C. Frohne and D. A. Sleeper, U. S. Public Health Service; also to the pilot Lt. Barney Carlson U. S. Air Force, whose precision flying aided immensely in proper distribution of the spray; and Earl Welch of the Alaska Air Installations Office and Capt. Harry Stierli of the U. S. Public Health Service who contributed the services of the Alaskan Command plane on the large missions and assisted in operations.
[4] *Paceosol.* In the paper by Blanton *et al.* (1949) chlorinated camphene was erroneously indicated as an ingredient of all the airplane spray formulations used in the 1948 tests. *Velsicol AR-50* should be substituted for chlorinated camphene in all these formulations.
[5] *Triton B-1956*
[6] *Triton X-100.*
[7] *Velsicol AR-50G.*

counts and sometimes two or more observers made counts at the same station.

INFILTRATION OF MOSQUITOES INTO SPRAYED AREAS. *Eielsen Field.*—An area 10 miles square at Eielsen Field was sprayed on May 26 and 27 for the control of larvae, and after 48 hours 94 per cent of the larvae were killed. Details of the results obtained with larvae are presented in another paper (Travis *et al.* 1950), but the observations on infiltration of mosquitoes into the sprayed area from outside are included herein (table 1).

On June 5 there was a heavy emergence of *Aëdes* just outside the sprayed area. Hordes of teneral mosquitoes observed in the low brush made little or no attempt to alight on the observers or to bite. Within 3 days after emergence they were in the center of the plot in annoying numbers.

The first spraying of adults was made on June 14–15. Because of its large size half the plot was sprayed during the day and the other half at night. The south half, sprayed at night, showed a reduction of 92 per cent 24 hours after spraying, whereas the north half, sprayed during the day, showed some increase in the number of mosquitoes. After 48 hours the south half showed a reduction of 84 per cent and the north half 27 per cent. It is not understood why there was an increase the first night and a reduction on the second night after spraying, unless these mosquitoes were killed by delayed action of the DDT. Observations made on water during the entire spray operation showed that considerably more spray reached the ground during the night than during the day, which probably accounts for the poor results in the area sprayed during the day.

The second spraying of adults was started just before midnight on June 21 and finished around 7 A.M. on June 22. Total spray time was approximately 7 hours and 30 minutes. The spraying of such a large area in such a short time required excellent timing and teamwork between the ground crews and the crews of the planes. Radio communication between the two contributed a great deal to the timing. One plane was spraying while the tanks of the other one were being filled with spray, and by radio contact it was possible to have a continuous operation.

There was 95 per cent reduction of mosquitoes after 24 hours and 87 per cent after 48 hours. Although this spraying was effective for about 2 weeks, is is not considered practical from an economic standpoint to attempt control over such large areas unless a single treatment would be effective for an entire season.

Clear.—A plot of 16 square miles at Clear, located about 75 miles south of Ladd Field, was sprayed on June 30, 1949, at the rate of 0.05 pound of DDT per acre. This test was unique in spraying with a C-47 because the landing flap was lowered 15° during the entire operation. The outstanding down-draft created by this procedure drove the spray to the ground. This treatment reduced the average mosquito landing rate from 19.6 to 4 per minute or 80 per cent.

Umiat.—A 24-square-mile plot at Umiat, located approximately 150 miles southeast of Point Barrow on the Colville River, was sprayed on June 12, 1949, at the rate of 0.1 pound of DDT per acre. Spraying was begun 10 minutes after midnight. Umiat is considerably north of the Arctic Circle and is in the tundra country. The terrain consists of low, rolling hills, with low-growing brush, primarily of willow and scrub birch, in the river flood plain.

The populations of mosquitoes at Umiat were much greater than any the writers had ever experienced in other parts of Alaska. In 11 counts of landings on the back of a woolen glove, the numbers of mosquitoes ranged from 47 to 100, with an average of 70 per minute. The estimated landing rate on the front of the clothes was 364.

The initial kill, 98 per cent, was based on counts made 13 hours after the spraying. The same degree of control was indicated by both types of landing-rate counts. Counts made after 19 hours showed a reduction of 95 per cent, but hordes of mosquitoes were observed flying back into the sprayed area. The original population was so high that even with 95 per cent control there were enough mosquitoes left to give landing rates as high as 50 per minute on the front of the trousers. Control was estimated to be 93+ per cent by the trouser counts.

It is not known how large an area would have to be sprayed to give protection from mosquitoes in such treeless tundra, but

Table 1.—Average landing rate (number per minute) of adult mosquitoes on various dates at different distances from the center of a plot treated several times from the air on June 14–15 and 21–22 with 0.1 pound of DDT per acre.

Distance from Center of Plot (Miles)	June											July			
	7	9	12	13	16	17	21	23	24	25	28	2	3	5	8
South half															
7 (check area)	—	—	—	—	28	37	56	28	40	36	26	52	58	28	35
6 (check area)	—	24	40	50	12	28	51	18	41	42	28	49	55	52	26
4.5	4	7	31	53	4	6	8	0	6	0.5	0	3	22	2	2
3.5	6	6	14	42	2	9	16	0.5	2	0	0.5	4	21	4	9
2.5	6	13	38	38	2	6	5	0	0	0	0	2	14	0.5	0.5
1.5	3	15	23	30	2	6	39	0	2	1	0.5	6	31	0	17
0.5	2	6	8	20	5	2	8	0	0.5	1	0.5	2	14	5	8
North half															
0.5	—	8	29	20	45	9	7	2	2	0	1	1	10	0	4
1.5	—	8	42	9	18	8	9	0	0	0	0.5	2	19	4	4
2.5	—	7	28	35	23	6	9	1	3	0	2	4	15	1	14
3.5	—	4	16	22	12	23	38	1	2	0	0.5	4	10	4	20
4.5	—	4	14	16	23	29	9	2	0.5	3	0.5	5	4	10	10
6 (check area)	—	24	16	25	76	68	64	7	32	8	10	12	46	47	34
8 (check area)	—	—	—	—	—	—	—	8	44	21	15	42	44	41	41

the area would doubtless be too large to be practical.

Oumalik.—The plot at Oumalik was located approximately 100 miles due south of Point Barrow. Like Umiat, Oumalik is north of the Arctic Circle and in the tundra area. The general terrain is flat with numerous small lakes.

The mosquito population was much lower at Oumalik than at Umiat. At 15 selected counting stations there was an average of only 45 mosquitoes landing per minute before spraying. Approximately 16 square miles were sprayed beginning at 8:30 P.M. on July 12. The velocity of the wind was around 10 miles per hour at the time of spraying.

No mosquitoes were observed 12 hours after treatment, and an average of only two mosquitoes per station, or a reduction of 96 per cent, was observed 24 hours later. This average lasted for 3 days.

SMALL-PLOT TESTS.—Fourteen plots, each 4 square miles in area, were sprayed with the various formulations during the nights of July 5 and 6. All tests were duplicated, except that only one plot each was treated with the 5 per cent spray. The plots were near Big Delta, Alaska, and extended from Big Delta down the Alcan Highway for about 5 miles, and between Ladd Field and Eielsen Field.

Table 2 shows that some of the formulations were superior to the 20 per cent DDT airplane spray. In one plot sprayed with the emulsifiable concentrate at 0.05 pound of DDT per acre, the mosquito count was higher after the spraying than before. At dosages of 0.1 pound, however, this spray caused a greater reduction of mosquitoes than the sprays without the emulsifier. No better results were obtained with the 5 per cent than with the 20 per cent sprays even though the total volume of the 5 per cent material was four times that of the 20 per cent material.

Table 2.—Effectiveness of various formulations and dosages of DDT against adult mosquitoes in Alaska.

Formulation	Dosage per Acre		Average Landing Rate (Number per Minute) before Spraying[1]	Per Cent Reduction 24 Hours After Spraying
	Pints of Liquid	Pounds of DDT		
Airplane spray (20% DDT):				
Diluted to 5%	1	.05	37	70
	2	.1	35	89
Plus spreader[2] 1%	.25	.05	54	76
			33	64
	.5	.1	50	84
			39	95
Undiluted	.25	.05	46	42
			44	73
	.5	.1	36	81
			29	76
Emulsifiable concentrate (20% DDT)	.25	.05	32	Increase
			55	73
	.5	.1	47	91
			51	86

[1] In outside plots near the sprayed area, the landing rate averaged 34 mosquitoes in 71 observations made prior to spraying, and 35 mosquitoes in 85 observations made 10–18 hours after spraying.

[2] *Triton B-1956.*

DISCUSSION AND CONCLUSIONS.—The tests showed that sprayed areas were free of mosquitoes for only a short time, even

when the areas covered as much as 100 square miles. In addition to information on control, the treatment of such large plots also gave useful information on mosquito dispersion. A single DDT larvicidal treatment of a 100-square-mile area at Eielsen Field, Alaska, gave less than 3 days protection after the adult mosquitoes had emerged in surrounding untreated areas. Apparently adults disperse more rapidly immediately after they emerge, because the control was satisfactory for nearly 2 weeks when the same area was sprayed about a week after emergence. In the Eielsen Field area there is considerable spruce, which might serve as a partial barrier, but in the Umiat area there is no such barrier, and it is doubtful if protection for any length of time would be realized even with large-area spraying.

With the rapid movement of Alaskan mosquitoes and the vast breeding area, it is concluded that a single spraying of a large area is not practical and that multiple sprayings of smaller areas will give more satisfactory results. It is believed that 25 to 30 square miles is a practical area to treat, but it may be more desirable to treat even smaller areas for very temporary control. The dosage studies showed that 0.1 pound of DDT per acre was practical, but under ideal conditions 0.05 pound gave excellent control. The use of spreaders and emulsifying agents seemed to increase the effectiveness of the 20 per cent DDT airplane sprays.

SUMMARY.—At Eielsen Field, Alaska, large-scale spray tests with DDT for the control of mosquito larvae showed that adult mosquitoes infiltrated into an area of 100 square miles within 3 days after they emerged from adjacent untreated areas. When this same area was sprayed to control adult mosquitoes, infiltration was sufficiently great to require another application in about 2 weeks. In the tundra area at Umiat, Alaska, mosquitoes infiltrated into a 16-mile area within 13 hours. Formulation studies indicated that a 20 per cent DDT airplane spray could be improved by the use of spreaders or emulsifiers. The tests confirmed that 0.1 pound of DDT is a practical dosage and that nothing is to be gained by diluting the 20 per cent spray to 5 per cent.

LITERATURE CITED

Blanton, F. S., C. N. Husman, B. V. Travis, and C. S. Wilson. 1949. Control of Alaskan mosquito adults by aerial sprays. JOUR. ECON. ENT. **42**: 106–9.

Husman, C. N. 1949. Spray equipment for C-47, UC-64, and L-5 airplanes. Mosquito News. 9(4): 166–70.

Travis, B. V., K. H. Applewhite, and Nelson Smith. 1950. Control of mosquito larvae in Alaska with DDT. JOUR. ECON. ENT. **43**(3): 350–3.

Control of Mosquito Larvae in Alaska with DDT[1]

B. V. TRAVIS,[2] K. H. APPLEWHITE,[3] and NELSON SMITH, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[4]

As a part of a program to investigate insect problems in the subarctic, tests were continued in 1949 on the control of mosquito larvae in Alaska (Gjullin *et al.* 1949). Observations were made on the treatment of a 100-square-mile plot with DDT, and comparative tests were made with several formulations of DDT. The residual effect of DDT that had been sprayed on several plots in 1948 as a prehatching treatment was also observed.

The mosquito larvae in the test plots ranged from the second instar to pupae, but most of them were in the third and fourth instar.

OBSERVATIONS ON 100-SQUARE-MILE PLOT.—In the 100-square-mile plot a C-47 airplane equipped with wing spray bars was used to apply a 20 per cent DDT airplane spray to which 1 per cent of spreader[5] had been added. The spray contained 20 per cent of DDT, 20 per cent of fuel oil, and 60 per cent of an aromatic

[1] This work was conducted under funds allotted by the National Military Establishment to the Bureau of Entomology and Plant Quarantine.

[2] Now with Cornell University.

[3] Captain, Office of the Quartermaster General, U. S. Army.

[4] The writers wish to acknowledge the assistance of C. N. Husman and the pilot, Lt. J. T. Woodyard, in the application of the sprays, and of Lt. Col. F. S. Blanton in the checking of the plots.

[5] *Triton B-1956.*

hydrocarbon solvent,[1] and was applied at the rate of 0.1 pound of DDT per acre. The entire plot was 10 miles on each side; however, it was not necessary to spray nearly 20 square miles of land located in a wide river bottom and on the tops of the several hills in the plot. A total of 3570 gallons of spray was applied in a flying time of 8 hours and 30 minutes. In making the swaths the pilot was guided by smoke signals and by radio. The plane was oriented over the smoke signal, and the pilot kept the long swaths parallel by means of a compass. Population counts were made before and 48 hours after the spraying. Random dips were taken every half-mile across a 10-mile transect through the center of the plot, and at half-mile intervals for 2.5 miles along a perpendicular line extending in one direction from the midpoint of the transect.

A total of 2110 dips showed a population prior to treatment of 6403 larvae and 30 pupae. After 48 hours 1609 dips showed a population of 314 larvae and 16 pupae, a control of 93 per cent.

COMPARATIVE TESTS WITH SEVERAL FORMULATIONS OF DDT.—The formulations used in the comparative tests included the 20 per cent DDT airplane spray; the 20 per cent spray with 1 per cent of spreader[2] added; the 20 per cent spray diluted to 5 per cent of DDT with fuel oil; and an emulsifiable concentrate containing 20 per cent of DDT, 10 per cent of emulsifier (monoisooctyl phenyl polyethylene glycol ether),[3] and 70 per cent of solvent (chiefly methylated naphthalenes).[4] Two dosages of each formulation, 0.05 and 0.1 pound of DDT per acre, were applied from a Norseman plane (UC-64) equipped with wing booms. Two 10- to 25-acre plots were included in each treatment. Five dips were made prior to each treatment and also 24 and 48 hours after treatment in each of five marked pools selected at random in each plot.

As shown in table 1, the 0.1-pound dosages were all highly effective, giving average larval reductions of 97 to 100 per cent. With the 0.05-pound dosages the control varied from 88 to 96 per cent. The poorest results were obtained with the 20 per cent spray, indicating that the use of a larger quantity of diluted spray or the addition of the spreaders increased the effectiveness to some extent. There was some evidence of faulty distribution of the sprays at the margins of the plots treated with the last two formulations, so the percentages probably should have been higher for these treatments.

Table 1.—Mortality after 48 hours of mosquito larvae in small plots sprayed from the air with various formulations of DDT.

Formulation	Dosage per Acre		Average Number of Larvae per Dip	Per Cent Mortality
	Pints of solution	Pounds of DDT		
Airplane spray (20% DDT):				
Diluted to 5%	1	0.05	36.2	96
	2	.1	20.1	97
Undiluted	0.25	.05	13.2	88
	.5	.1	25.7	99+
Plus spreader[1] 1%	.25	.05	7.0	95
	.5	.1	13.9	100
Emulsifiable concentrate (20% DDT)	.25	.05	19.5	93
	.5	.1	14.3	99+

[1] *Triton B-1956.*

OBSERVATIONS ON PREHATCHING TREATMENTS.—Observations were made on two large areas that had been sprayed with DDT in the summer of 1948 and on six small plots that had been sprayed in the fall for the control of mosquitoes. The large areas, Eielsen and Ladd Fields, had been sprayed at the rate of 0.3 pound of DDT per acre and the small plots at 0.5 and 1 pound of DDT. Incidental checks were also made on 28 small experimental plots near Anchorage that had received prehatching treatments in the fall of 1947 or in the spring of 1948 (Travis *et al.* 1949). Most of the checks were made on plots showing little or no breeding in the first season after treatment. Larval counts were made in the same manner as in the large-scale test.

At Eielsen Field, in a 25-square-mile plot, a total of 5643 larvae and pupae were taken in 1033 dips outside the plot and 1068 larvae and pupae in 1466 dips inside the plot, a reduction in breeding of 86 per cent caused by the spraying of the previous season.

Observations at Ladd Field were limited because of flood conditions, but the 24-square-mile area that was checked was considered representative of the plot. Two

[1] *Paccosol.*
[2] *Triton B-1956.*
[3] *Triton X-100.*
[4] *Velsicol AR-50-G.*

types of environment, grassy swales and moss-heath-scrub birch, were available for the study in this plot. In the swales of grass (*Calamagrostis canadensis*) 671 larvae were taken in 47 dips outside the plot and only 5 larvae in 128 dips inside the plot, a reduction of 99 per cent. This check area was a striking one as there was also a considerable reduction in the marginal area where the spray was shut off and the plane made its turn. In this zone 73 larvae were taken in 47 dips. In the moss-heath-scrub birch environment the treatment was less effective. A total of 319 larvae were taken in 96 dips outside the treated plot and 63 larvae in 164 dips inside the plot, a difference of 90 per cent.

The six plots that received pre-hatching treatments in the fall of 1948 were located in three environments—a sedge area near Gulkana, a scrub birch-*Myrica* area near Anchorage, and a moss-heath-scrub birch area near Fairbanks. In the sedge area the 0.5-pound dosage gave 97 per cent mortality and the 1-pound dosage 99 per cent. No control was obtained with the 1-pound dosage in the scrub birch-*Myrica* plots, and the 30 per cent kill obtained in the birch-*Myrica* association with the 0.5-pound was considered a sampling variation, as the 1-pound dosage gave no control. Circumstances made it impossible to dip in the moss-heath-*Myrica* association treated with the 1-pound dosage, but there were more larvae in the plot treated with the 0.5 pound dosage than in the untreated check area.

On the 28 small plots that had been treated with DDT in the fall of 1947 or in the spring of 1948, only 3 of the treatments were considerably less effective than they were in 1948. One of the plots had been treated with 1 pound of a 10 per cent dust, one with 0.5 pound of a 5 per cent spray, and one with 0.1 pound of a 1 per cent spray. Checks of plots on which treatments were not effective in 1948 also showed a high larval count in 1949. In a plot that had been treated with 2 pounds of DDT per acre by airplane in August 1947, one newly hatched larva was seen in 1948 and none in 1949. Large larvae transferred to this plot in 1949 were nearly all dead after 48 hours. This location was a grassy swale and obviously the treatment was still effective. Most of the residues that were effective for two seasons after treatment were in grassy swales or moss-heath environments that had been treated with 0.5, 1, or 2 pounds of DDT per acre.

DISCUSSION.—The reduction in mosquito breeding due to DDT treatments in previous seasons indicated the desirability of applying dosages of at least 0.3 pound of DDT per acre over large areas in Alaska immediately surrounding places of habitation. Observations should be continued on such areas to determine whether the material can be expected to carry through more than two seasons, as is indicated by the small-plot treatments. It is conceivable that, if sufficiently large blocks of land are adequately treated, mosquito control in the arctic and subarctic regions might be less of a problem than has been anticipated. Certainly the total mosquitoes in an area close to a military base or village might be kept low for one or more seasons by one application, and therefore the major effort would be directed at controlling the mosquitoes that invade the area from untreated adjacent lands.

The environments most effectively controlled by the applications of the previous year were the grassy swales. This is a confirmation of the previous observations.

There is no way of knowing what caused the reductions of mosquitoes in these large plots. No doubt considerably fewer eggs were laid in the plots because of the treatments. In addition it seemed that the DDT present was operating as a prehatching treatment. The very clear line of demarcation between the treated and the untreated areas was proof that residual DDT was present in the treated areas.

SUMMARY.—In tests against mosquito larvae in Alaska, a dosage of 0.1 pound of DDT per acre was highly effective and gave slightly higher mortalities than a dosage of 0.05 pound. Airplane spray formulations containing 20 per cent of DDT and either 1 per cent of polyglyceride of a glyptal resin or 10 per cent of monoisooctyl phenyl polyethylene glycol ether were more effective than the 20-per cent DDT spray without these materials added. At 0.1-pound dosages the 20 per cent spray was slightly more effective than a 5 per cent spray.

One year after routine spray applications that totaled 0.3 pound of DDT per acre, there were 86 to 99 per cent fewer larvae in the treated marshes than in

adjacent untreated marshes. The residues on many plots treated in the fall of 1947 or the spring of 1948 were still effective in the spring of 1949. Nearly all the large larvae transferred to one of these plots that had been treated with 2 pounds of DDT per acre in fuel oil were dead after 48 hours. Sedge plots treated with 0.5 and 1 pound of DDT per acre by airplane in the fall of 1948 showed 97 and 99 per cent reduction in mosquito larvae, respectively, in the spring of 1949. Plots similarly treated in scrub birch-*Myrica* and in moss-heath-*Myrica* environments showed little or no reduction in larval populations.

LITERATURE CITED

Gjullin, C. M., C. S. Wilson, B. V. Travis, and G. L. Hutton. 1949. The relative effectiveness of several insecticides against mosquito larvae in Alaska. Mosquito News (In press.)

Travis, B. V., C. M. Gjullin, F. S. Blanton, N. Smith, and C. S. Wilson. 1949. Prehatching treatments for the control of *Aëdes* in Alaska. Mosquito News 9: 42–8.

Field Tests with Mosquito and Sand Fly Repellents in Alaska[1]

K. H. APPLEWHITE[2] and CARROLL N. SMITH[3,4]

During June and July 1948 a study of insect repellents was undertaken as a part of a general investigation of insects attacking man in Alaska (Travis 1949). In extensive, sparsely inhabited regions such as Alaska, protection of individuals against mosquitoes and other biting insects often depends on the use of repellents and protective clothing. The repellents selected for testing in Alaska were those that had shown outstanding effectiveness in tests at Orlando, Fla., and elsewhere. They were tested in several localities as skin treatments or as clothing impregnants against various species of mosquitoes and one species of sand fly (Culicoides).

TOXICITY CLASSIFICATION.—The toxicity classification ratings shown in the tables represent the authors' interpretation of results submitted from tests conducted by the U.S. Food and Drug Administration of the Federal Security Agency for the armed forces when the repellent was used as shown in this paper. These ratings are explained below.

1—Deemed safe for use.
2—No data.
3—Formulation not tested as mixture. Individual ingredients deemed safe.
4—Not deemed safe or insufficient data.
5—Deemed safe as impregnite at levels up to and including 2.0 grams per square foot.
6—Deemed safe for restricted use or with caution.

TESTS AGAINST MOSQUITOES.—*Skin Applications.*—All liquid repellents were tested at a concentration of 25 per cent in alcohol; as tests at Orlando had shown that reliable evaluations of repellents could be made in this manner with shorter exposures than were required for full-strength applications. The method was particularly desirable in Alaska because of the limited time and man power available, and because of the variation in insect activity over a prolonged period due to changes in temperature and wind velocity.

Materials were tested on the arms, 1 ml. of 25-per cent solution being applied over the forearm from wrist to elbow. Nine subjects were used in testing 10 materials, each subject testing 2 repellents at a time, 1 on each arm. Each repellent was tested once on each subject and paired once (tested on opposite arms of the same subject) with each of the other materials. This procedure involved 5 exposures, usually 2 a day, in the morning and afternoon. Exposures were made in localities where mosquitoes were numerous and where the biting rates on un-

[1] This work was conducted under funds allotted by the National Military Establishment to the Bureau of Entomology and Plant Quarantine.

[2] Captain on duty on Research and Development Branch, Office of the Quartermaster General, U. S. Army, Washington, D. C.

[3] Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, U. S. Dept. of Agriculture, Orlando, Fla.

[4] The authors are indebted to B. V. Travis, Bureau of Entomology and Plant Quarantine, director of the Alaska Insect Project; Maj. J. E. Barnhill, Office of the Quartermaster General U. S. Army; Lt. Col. F. S. Blanton, Office of the Surgeon General U. S. Army; and particularly to G. E. Nielsen, Bureau of Entomology and Plant Quarantine and W. C. Frohne, Lt. Col., U. S. Public Health Service who assisted in many of the field tests. Several officers and enlisted men of the Alaskan Command also gave valuable assistance in conducting these studies.

Table 1.—Relative effectiveness of liquid repellents as skin treatments against Alaskan *Aëdes*. Anchorage, June 29 to July 3 (9 tests each); Big Delta, July 8–12 (9 tests each), and July 16–18, 1948 (5 tests each).

Repellent	Toxicity Classification	Minutes to First Bite[1]			
		Anchorage		Big Delta[2]	
		Range	Average	Range	Average
Propyl N,N-diethylsuccinamate	1	9–334+	178+	12–174	92
				24–339	154
Mixture 6-2-2 (dimethyl phthalate 60%, *Repellent 6-12* 20%, and *Indalone* 20%)	1	15–175	114	34–123	76
				35–288	167
Repellent 6-12 (2-ethyl-1,3-hexanediol)	1	37–170	115	17–126	71
				65–214	170
Dimethyl phthalate	1	19–147	102	16–213	94
				41–198	140
4-(*p*-Methoxyphenyl)-5-methyl-1,3-dioxane	6	8–212	113	9–123	40
				8–98	56
Indalone (butyl ester of 3,4-dihydro-2,2-dimethyl-4-oxo-1, 2H-pyran-6-carboxylic acid)	1	43–226	117	8–87	34
				14–67	32
2,2′-Thiodiethanol diacetate	1	29–212	113+	9–121	42
Pentamethylene propionate	1	10–198	92	10–93	37
Ethyl beta-phenylhydracrylate	1	34–142	82	6–160	50
Butyraldehyde, 2-ethyl-2-nitro-1,3-propanediol acetal	6	10–197+	88+	6–91	24

[1] Plus signs indicate termination of one or more of the tests before the first bite was received.
[2] Results are shown for two series of tests at Big Delta with six of the compounds.

treated arms were adequate. Protection time was figured to the first confirmed bite (*i.e.*, confirmed by a second bite within 30 minutes).

The results of these tests are shown in table 1. In tests in the Anchorage area against *Aëdes flavescens* (Muell.), propyl N,N-diethylsuccinamate was by far the most effective material tested, with a protection time of more than 178 minutes. Five other materials were about equal in effectiveness, with average protection times of 113 to 117 minutes, and the other four were effective for 82 to 102 minutes.

In the Big Delta area all the repellents were less effective against *Aëdes excrucians* (Walk.), *A. communis* (Deg.), and *A. pionips* Dyar than in the tests at Anchorage, some showing less than half the protection time. Propyl N,N-diethylsuccinamate and dimethyl phthalate gave the best results, with protection times of 92 and 94 minutes, respectively. The next most effective repellents were Mixture 6-2-2 and *Repellent 6-12*, both of which were among the six best materials tested at Anchorage.

In another series of tests at Big Delta, under somewhat different weather conditions, the six most effective repellents were retested. They were tested once on each of five subjects and paired once with each of the other repellents. In this series *Repellent 6-12* and mixture 6-2-2 were equally effective and superior to the other four. Propyl N,N-diethylsuccinamate and dimethyl phthalate were slightly less effective, whereas *Indalone* and 4-(*p*-methoxyphenyl)-5-methyl-1,3-dioxane were definitely inferior. Even though a much longer protection time was afforded with five of the materials in this test than in the previous one at Big Delta, the same four repellents were the most effective.

In a series of tests at Big Delta and Eielsen Field with mixtures of repellents (table 2), a mixture containing 6 parts of dimethyl phthalate, 4 parts of propyl N,N-diethylsuccinamate, 2 parts of *Indalone*, and 2 of *Repellent 6-12* was the most effective. Propyl N,N-diethylsuccinamate alone was superior to the mixture containing *Repellent 6-12* and as effective as the mixture containing *Indalone*.

In a small series of tests at Big Delta a proprietary cream containing dimethyl carbate (dimethyl ester of cis-bicylo[2.2.1]-5-heptene-2,3-dicarboxylic acid) substituted for *Repellent 6-12* in a 6-2-2 mixture was paired with the standard mixture 6-2-2 and two other repellents. The formula of the cream as given by the manufacturer was 41.4 per cent of dimethyl

Table 2.—Relative effectiveness of three liquid repellent mixtures as skin treatments against Alaskan *Aëdes*. Big Delta and Eielsen Field, July 16–18, 1948. (Each repellent tested once on three subjects.)

Repellent	Toxicity Classification	Minutes to First Bite	
		Range	Average
Dimethyl phthalate, 6 parts *Indalone*, 2 parts *Repellent 6-12*, 2 parts Propyl N,N-diethylsuccinamate, 4 parts	3	147–273	189
Dimethyl phthalate, 6 parts *Indalone*, 2 parts Propyl N,N-diethylsuccinamate, 2 parts	3	72–300	168
Dimethyl phthalate, 6 parts Repellent 6-12, 2 parts Propyl N,N-diethylsuccinamate, 2 parts	3	87–173	134
Propyl N,N-diethylsuccinamate	1	111–215	167

phthalate, 13.8 per cent each of dimethyl carbate and *Indalone*, 30 per cent of zinc stearate, and 1 per cent of bentonite. The results are shown below.

Repellent	*Minutes to First Bite*
Proprietary cream	90
Mixture 6-2-2	86
Proprietary cream	159
Mixture 6-2-2	169
Proprietary cream	212[1]
Mixture 6-2-2	206
Proprietary cream	249
Propyl N,N-diethylsuccinamate	402
Proprietary cream	—[2]
Propyl N,N-diethylsuccinamate	228[1]
Proprietary cream	321
Test mixture (dimethyl phthalate 6 parts; propyl N N diethylsuccinamate 4 parts; *Repellent 6-12* 2 parts; and *Indalone*, 2 parts)	239

[1] Unconfirmed first bite.
[2] No bites after 228 minutes.

Another series of tests was conducted at Anchorage with a group of cream repellents prepared by the Army Chemical Corps. The principal species present was *Aëdes flavescens*. In these tests 25-per cent alcoholic solutions of the repellents were compared with creams consisting of approximately 20 per cent of the same repellents, 12 per cent of glycerol, 5 per cent of resin blend, 5 per cent of bentonite, and 58 per cent of water. In 18 tests the creams were slightly less effective than the liquids. Since the liquids would normally be used at full strength, it was obvious that they would be much more effective than the cream preparations.

In general propyl N,N-diethylsuccinamate was more effective against Alaskan *Aëdes* than any of the other repellents tested. It was outstandingly more effective in one of the three series of tests, and about as effective as any in the other two, from the standpoint of average time to the first bite. There was no significant difference in effectiveness between dimethyl phthalate, *Repellent 6-12*, and mixture 6-2-2. *Indalone* and 4-(*p*-methoxyphenyl)-5-methyl-1,3-dioxane gave good results in the first series, but were considerably less effective in the other two. The average protection times in all tests for the six repellents that gave the best results in the first series were as follows:

Repellent	*Minutes to First Bite*
Propyl N,N-diethylsuccinamate	139+
Mixture 6-2-2	112
Repellent 6-12	110
Dimethyl phthalate	107
4-(*p*-Methoxyphenyl)-5-methyl-1 3 dioxane	72
Indalone	66

APPLICATIONS ON CLOTHING.—Cotton stockings impregnated with repellents were tested for durability of the treatments through aging, rinsing in water, and wearing. Thirty-five repellents that were outstanding in previous tests against salt-marsh mosquitoes were used. The stockings were impregnated with 3 grams of repellent per square foot of cloth (6.6 grams per stocking), dissolved in acetone (50 ml. per stocking). After evaporation of the acetone, the stockings were placed

Table 3.—Durability of mosquito repellents impregnated in cotton fabrics. Anchorage, June 30 to July 13; and Big Delta, July 8–24, 1948.

Repellent	Number of Rinsings Withstood		Hours of Wear Withstood[1]		Toxicity Classification
	Anchorage	Big Delta	Rinsed After 8 Hours	Rinsed After 8 and 16 Hours	
Repellents effective after four rinsings and 16 hours of wear					
Hexyl mandelate	13	4	24+	40+	5
Indalone	6	4	24+	32	1
2-2-[(2-Ethylhexyloxy)ethoxy]ethanol	5	5	24+	32	1
Cyclohexanepropionic acid	7	7	8	24	4
Acetamide, alpha, alpha, alpha-trichloro-N-(2-chl roethyl)-	6	5	24+	24	6
N-Butylhexahydrophthalimide	6	4	24+	16	2
N-Butyl-1,2,3,6-tetrahydrophthalimide	4	4	24+	16	5
Caprylic acid	4	6	16	16	5
Allyl alpha-beta-epoxy-beta-phenylbutyrate	5	4	24+	16	2
Isoborynl 4-morpholineacetate	6	3	24+	16	1
Repellents not effective after four rinsings and 16 hours of wear					
alpha-Butoxy-N-cyclohexyacetamide	3	4	24+	40+	5
Ethyl ester of 3,4-dihydro-2,2-dimethyl-4-oxo-1,2H-pyran-6-carboxylic acid	4	1	24+	24	4
N-Amyl-alpha-butoxyacetamide	3	3	24+	16	4
Mixture 6-2-2	3	4	24+	16	1
2,4-Decanediol	3	2	24+	16	2
p-sec-Butoxybenzyl alcohol	4	1	24+	16	2
Butyl sulfone	3	0	24+	16	2
2-Methylhendecanal	9	4	0	24	4
Isopropyl beta-phenylhydracrylate	3	2	24+	8	2
N,N-diisoamylacetamide	4	4	8	16	2
Dimethyl phthalate	3	3	16	16	1
Cinnamyl alcohol	3	2	16	16	5
2-Butyl-2-ethyl-1,3-propanediol	3	1	8	16	1
Repellent 6-12	2	1	8	16	1
alpha-(2-Butoxyethoxy)-N-cyclohexylacetamide	3	1	8	16	5
1,2,3,4-Tetrahydro-2-naphthol	2	4	8	16	4
Ethyl beta-phenylhydracrylate	3	2	8	16	1
Dodecanal	3	2	8	8	4
1,3-Propanediol monobenzoate	3	1	8	8	2
5-Ethyl-2,4-heptanediol	3	1	8	8	2
2,3-Octanediol	3	1	8	8	2
Propyl N,N-diethylsuccinamate	2	1	8	8	1
Methyl beta-phenylhydracrylate	1	0	8	8	2
3-(1,3-Dimethylbutoxy)-1,2-propanediol	3	0	8	8	4
2-(2-Hexyloxyethoxy)ethanol	2	0	8	8	4

[1] Plus signs indicate stockings still effective when last tested.

in individual paper bags, and were removed only for rinsing or testing.

In the aging tests the stockings were tested at intervals. In the rinsing tests the stockings were immersed in cool water, stirred for a few seconds, and then wrung by hand (repeated five times at each rinsing). In the wearing tests the stockings were tested after each 8 hours of wear. As the time available for testing was short, the effect of wearing was hastened by rinsing, after 8 hours of wear in one series of tests and after 8 and 16 hours in another.

Stockings were tested by exposing them for 10 minutes on the arms or legs of subjects in areas of heavy natural infestation. Before the tests bare arms or legs were exposed to determine whether the biting rate was satisfactory. Each stocking was tested on three subjects in succession, and was considered effective if the average number of bites per subject was less than five.

Results in the rinsing and wearing tests are shown in table 3. Hexyl mandelate was slightly superior to most of the other repellents in resistance to wearing, and withstood 13 rinsings in one test but only four in another. The next most resistant

materials were alpha-butoxy-N-cyclohexylacetamide, *Indalone*, and 2-[2-(2-ethylhexyloxy)ethoxy]ethanol in the wearing tests, and cyclohexanepropionic acid in the rinsing tests. Several of the other materials were only slightly less resistant to rinsing or wearing than those named. The 4 most effective repellents on the skin made comparatively poor showing in these tests.

All repellents were effective after 12 days of aging, and no later tests were made.

TESTS AGAINST SAND FLIES.—Tests against sand flies were conducted at Valdez, Alaska, where the predominant species was *Culicoides tristriatulus* Hoffman.

Face masks of 6-, 8-, and 10-mesh cotton netting were treated with repellents and tested for effectiveness in protecting the face. The masks resembled small, close-fitting head nets, but were made with openings at the eyes to permit better vision, and at the mouth to permit smoking or eating. They were treated with 2 grams of repellent in acetone solution per square foot of cloth, estimated exclusive of the area of the interstices. Four repellents that had given the best results in skin applications were used. Two masks of each mesh were treated with each repellent.

Tests were made with five subjects, wearing masks of the same mesh; four of the masks were treated and one was untreated. Counts were made of the sand flies that penetrated the masks and bit. When 25 bites had been counted on the subject wearing an untreated mask, tests were discontinued. Exposure periods required to secure this number varied from 4 to 16 minutes.

Although biting was reduced to some extent, none of the masks gave adequate protection. Most of the penetration of the masks was through the mesh of the fabric rather than through the eye or mouth openings. With the finest mesh, averages of the two replications showed that from 2 to 4 bites were received in 6 to 16 minutes. The repellents used in these tests and the average number of bites (2 replications) obtained with the various meshes were as follows:

Repellent	*6-mesh*	*8-mesh*	*10-mesh*
No treatment	25	25	25
Propyl N,N-diethyl-succinamate	4	11	4
Ethyl beta-phenylhydracrylate	7	4	2
Dimethyl phthalate	6	1	2
Mixture 6-2-2	1	8	2

SUMMARY.—Field tests were made in Alaska with 10 repellents used as 25-per cent solutions on the skin. Six of these repellents were effective for 113 minutes or more against *Aëdes flavescens* (Muell.), and 7 for 34 minutes or more against *A. excrucians* (Walk.), *A. communis* (Deg.), and *A. pionips* Dyar. Propyl N,N-diethyl-succinamate was the most effective against *A. flavescens*, whereas this material and dimethyl phthalate, which were about equally effective, afforded better protection than the other materials against the mixed population of *Aëdes*. Cream preparations containing 20 per cent of the 10 repellents were slightly less effective than 25 per cent concentrations of the repellents applied as liquids.

In tests with 35 materials applied to fabrics, 10 were found effective against mosquitoes after four rinsings and 16 hours of wear. Hexyl mandelate, which was the most effective, withstood 13 rinsings and 40 hours of wear. Repellents applied to mesh face masks failed to give adequate protection from sand flies.

LITERATURE CITED

Travis, B. V. 1949. Studies of mosquito and other biting-insect problems in Alaska. JOUR. ECON. ENT. 42(3): 451–7.

Dr. Alvah Peterson, Professor of Entomology in the Department of Zoology and Entomology, Ohio State University, has been appointed Supervisor of the Entomology Division of the Department. His duties will be to supervise and direct the entomology teaching and research program.

Acute Toxicity of Chlorinated Insecticides Applied to Livestock[1]

R. D. Radeleff, *Bureau of Animal Industry* and R. C. Bushland, *Bureau of Entomology and Plant Quarantine, Agr. Res. Adm., United States Department of Agriculture*

Preliminary tests of the acute toxicity of chlorinated hydrocarbon insecticides for livestock have been described by Bushland, *et al.* (1948). Those workers applied DDT, methoxychlor, 2,2-bis-(p-chlorophenyl)-1,1-dichloroethane (TDE), chlordane, toxaphene and benzene hexachloride (10 to 12 per cent gamma isomer) as sprays or dips to cattle, sheep, goats, pigs, and horses. Using animals 9 months of age or older (except pigs, 3 months old) they were unable to induce insecticide poisoning with any of the insecticides other than chlordane by applying emulsions or suspensions at an insecticide concentration of 1.5 per cent, 8 times at 4-day intervals. Some sheep and goats were killed by 3 or more treatments with chlordane emulsions and suspensions in 1 of 2 series of experiments. Those authors also described a field test in which groups of 10 adult cattle were sprayed with suspensions of the same insecticides at 2 per cent concentration at 2-week intervals. Four applications of chlordane wettable powder caused the death of 3 of 10 cattle but other groups were apparently unaffected by 9 applications of the other insecticides. It was pointed out in that paper that the treatments were more severe than would ordinarily be used in livestock pest control, both from the standpoint of concentrations applied and frequency of retreatment. From that work it appeared that all the insecticides except possibly chlordane could be safely used on mature farm animals, in dosages likely to be used in livestock pest control, without producing clinical evidence of toxicity, and that chlordane did not cause acute poisoning at ordinary concentrations and frequencies of application.

In the spring of 1948 a toxaphene emulsion concentrate became commerically available to livestock growers. The material was sold for use at a maximum concentration of 0.55 per cent insecticide and was widely used in Texas as a spray and dip for the control of ticks and flies on cattle. At the time the insecticide was first distributed, approximately one-third of the cattle treated were young calves. It was estimated that about 1,000,000 cattle were sprayed with, and 250,000 were dipped in, the toxaphene solution. The spray treatments seemed to cause no injury but there were several reports of fatalities among young calves following dipping. Although the death loss was estimated to be only about 0.1 per cent of the calves dipped, the losses tended to be concentrated on a small number of ranches. The reports were brought to the attention of the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture by the formulator of the dip and the manufacturer of the toxaphene. Following this a cooperative study was undertaken at the Bureau's laboratory at Kerrville, Texas to determine whether poisoning by the insecticide could have been responsible for any of the losses among calves. These experiments revealed that calves are much more susceptible to toxaphene poisoning than are mature cattle. As a result, it became necessary to conduct further tests on young calves with all the chlorinated hydrocarbon insecticides which had previously appeared harmless to older animals.

Materials and Methods.—The problem of toxicity to suckling animals arose in the summer, a season during which very young animals of most classes of livestock are not available in the vicinity of Kerrville. It was possible to perform only a few tests with lambs and kids. Therefore, most of the work was directed to a study of the effects of the new insecticides on young calves, which were obtainable from dairies in the vicinity. Most of the calves were grade Jerseys, some were Jersey-Hereford crosses. Most of them were from 2 to 6 weeks of age.

The insecticides studied were all those mentioned in the introduction. The most thorough work was done with toxaphene since it was the first to be suspected in the field and time did not permit a complete evaluation of all the materials.

The insecticides were applied either as

[1] Report of a study made under the Research and Marketing Act of 1946.

sprays at low pressure, the animals being wetted as thoroughly as though they had been dipped, or by direct dipping. The standard formulation tested consisted of: 25 per cent insecticide, 65 per cent xylene, and 10 per cent of an aralkyl polyether alcohol.[1] Toxaphene, being readily soluble in xylene, was also formulated as a 65 per cent emulsion concentrate. Several tests were made with commerically formulated emulsion concentrates and wettable powders of the insecticides. All formulations were diluted with water on a weight in weight basis to obtain the desired concentration of insecticide.

Results with DDT.—Five calves were sprayed with 8.0 per cent DDT. With two of the animals the DDT was used in a suspension of 50 per cent wettable powder; with the remaining three animals, in a xylene emulsion. Four calves showed no ill effects. One calf lost weight but this condition was probably due to an infectious diarrhea rather than to insecticide poisoning.

Results with Methoxychlor.—Five calves were sprayed with 8.0 per cent methoxychlor—two with a suspension of 50 per cent wettable powder and the remaining three with a xylene emulsion concentrate. None of the animals appeared to be affected by the insecticide.

Results with TDE.—Five calves were sprayed with 8.0 per cent TDE—two with a suspension of wettable powder and three with a xylene emulsion. No ill effects were noted.

Results with Toxaphene.—Considerable exploratory work was performed with the use of toxaphene. Investigations dealt with the effects of inhalation of the diluted insecticide, ingestion of the material, and absorption following external application. The formulations used were xylene emulsion concentrates containing 25 and 65 per cent of the insecticide, a commercial kerosene emulsion concentrate containing 65 per cent toxaphene, and a commercially formulated 40 per cent wettable powder.

Effects of Inhalation.—Observations made at autopsy of calves dying after ranchers had dipped them in toxaphene frequently showed lung involvement which might have been due to inhalation of the dip. Therefore, sheep and goats were given intratracheal injections of 0.5 per cent toxaphene made by diluting the wettable powder and the xylene and kerosene emulsion concentrates in tap water. None of the insecticide mixtures caused any more pronounced symptoms than were induced by injections of tap water. The results indicated that toxaphene dips were no more likely to cause inhalation pneumonia than ordinary water.

Effects of Oral Administration.—Three-month-old calves, adult goats and adult sheep were given drenches containing toxaphene in doses ranging from 25 mg/kg to 50 mg/kg for the calves and from 50 mg/kg to 250 mg/kg for the goats and sheep. The drenches were prepared from a 65 per cent xylene emulsion concentrate, a 65 per cent kerosene emulsion concentrate and a 40 per cent wettable powder formulation diluted to either 0.5 per cent or 1.0 per cent insecticide. Each dose of insecticide tested was given to a group of three animals, but each animal within a group was given a different type of drench.

A summary of this experiment is given in table 1. The effect produced by any particular dose of the insecticide was fairly uniform in a group of animals tested. However, usually the xylene emulsion produced symptoms most rapidly and animals treated with a suspension of wettable powder were the last to be affected.

The 3-month-old calves tolerated a dose of 25 mg/kg, which represented a quantity of dip greater than was likely to be swallowed during ordinary dipping operations. A dose of 50 mg/kg was toxic to calves and adult goats but did not affect adult sheep. Sheep were affected by a dose of 100 mg/kg, although one animal survived oral administration of 250 mg/kg after showing symptoms of poisoning.

Some variation in reaction might be attributed to the function of the oesophageal groove in governing the deposition of material in deglutition.

It is probable that in animals reacting promptly to the dosage the drench material was diverted directly to the abomasum, whereas in those showing delayed or mild symptoms with the same dosage the material was diverted into the rumen and thereby mixed with the food content of that organ, resulting in a slower absorption rate. The same variability might be observed in instances of animals drinking vat or spray material. At identical con-

[1] *Triton X-100.*

Table 1.—Effects of oral administration of toxaphene formulations.

Animals Treated	Dose Toxaphene	Total Animals	Formulation Administered[1]	Number of Animals	Results
Calves (3-month-old)	25 mg/kg	3	XE-65	1	Unaffected
			KE-65	1	Unaffected
			WP-40	1	Unaffected
	50 mg/kg	3	XE-65	1	Died
			KE-65	1	Affected
			WP-40	1	Affected
Goats (Adult)	50 mg/kg	3	XE-65	1	Affected
			KE-65	1	Affected
			WP-40	1	Affected
	100 mg/kg	3	XE-65	1	Affected
			KE-65	1	Affected
			WP-40	1	Unaffected
	170 mg/kg	3	XE-65	1	Died
			KE-65	1	Affected
			WP-40	1	Affected
	250 mg/kg	3	XE-65	1	Died
			KE-65	1	Died
			WP-40	1	Died
Sheep (Adult)	50 mg/kg	3	XE-65	1	Unaffected
			KE-65	1	Unaffected
			WP-40	1	Unaffected
	100 mg/kg	3	XE-65	1	Affected
			KE-65	1	Affected
			WP-40	1	Died
	170 mg/kg	3	XE-65	1	Affected
			KE-65	1	Affected
			WP-40	1	Affected
	250 mg/kg	3	XE-65	1	Died
			KE-65	1	Affected
			WP-40	1	Died

[1] *XE-65* =An emulsion concentrate containing toxaphene 65 per cent, xylene 25 per cent, *Triton X-100* 10 per cent; *KE-65* =A commercially formulated emulsion concentrate containing 65 per cent toxaphene dissolved in kerosene; *WP-40* =A commercially formulated wettable powder containing 40 per cent toxaphene.

sumption rates some might be affected, others not.

EFFECTS OF SPRAYING.—Calves 2 to 6 weeks old were sprayed with three different formulations of toxaphene at concentrations ranging from 0.75 to 8.0 per cent It was not mechanically possible to spray the wettable powder at 8.0 per cent concentration, so this treatment was approximated by spraying the animals twice at 4.0 per cent concentration, the second treatment being applied as soon as the first spray had dried. Materials used at high concentrations were applied only once and the calves were observed for a period of 2 weeks following treatment. At lower concentrations some of the calves were sprayed repeatedly, an interval of 4 days being allowed between sprayings. In such cases observations were continued for 2 weeks following the last treatment. The results of the tests are shown in table 2.

The xylene and kerosene emulsion concentrates of toxaphene killed calves when the insecticide was applied at 8.0 per cent concentration and the animal sprayed with wettable powder was affected but recovered. When applied twice at 1.5 per cent concentration all three formulations produced toxic effects, 8 of the 12 calves treated being affected. Applied once at 1.0 per cent concentration, toxaphene caused the death of one of 11 calves, the others being unaffected. When applied 8 times at 0.75 per cent concentration the insecticide affected one of 12 calves.

Table 2.—Effects of toxaphene sprays applied to suckling calves.

Concentration of Toxaphene	Total Animals	Number Treatments[1]	Formulation Administered[2]	Number of Animals	Results
8.0%	3	1	XE-65	1	Died
			KE-65	1	Died
			WP-40	1	Affected
4.0%	3	1	XE-65	1	Affected
			KE-65	1	Unaffected
			WP-40[3]	1	Affected
1.5%	12	2	XE-65	4	2 Affected 2 Unaffected
			KE-65	4	1 Died 2 Affected 1 Unaffected
			WP-40	4	3 Affected 1 Unaffected
1.0%	11	1	XE-65	8	1 Died 7 Unaffected
			WP-40	3	3 Unaffected
0.75%	12	8	XE-65	4	1 Affected 3 Unaffected
			KE-65	4	4 Unaffected
			WP-40	4	4 Unaffected

[1] When animals were treated more than once, the interval between sprayings was 4 days.

[2] *XE-65* =An emulsion concentrate containing toxaphene 65 per cent, xylene 25 per cent, *Triton X-100* 10 per cent; *KE-65* =A commercially formulated emulsion concentrate containing 65 per cent toxaphene dissolved in kerosene; *WP-40* =A commercially formulated wettable powder containing 40 per cent toxaphene.

[3] Two consecutive sprayings of 4% concentration. See text.

Table 3 summarizes the results obtained with adult animals. A steer treated with 8.0 per cent toxaphene was affected but recovered. Twenty steers were sprayed with 4.0 per cent of the insecticide; 19 showed no ill effects, and 1 showed transitory symptoms of poisoning.

Two goats were killed and one was affected by 8.0 per cent toxaphene applied as a dip but three others were apparently unaffected by dipping in 4.0 per cent of the insecticide. Following dipping in 8.0 per cent toxaphene one sheep died and two were affected. Two sheep were affected by

Table 3.—Effects of toxaphene sprays or dips applied to adult animals.

Animals Treated	Concentration of Toxaphene	Total Animals	Number Treatments	Formulation Administered[1]	Number of Animals	Results
Steers	8.0%	1	1	XE-65	1	Affected
	4.0%	20	1	XE-65	7	1 Affected 6 Unaffected
				KE-65	6	6 Unaffected
				WP-40	7	7 Unaffected
Goats	8.0%	3	1	XE-65	1	Died
				KE-65	1	Died
				WP-40	1	Affected
	4.0%	3	1	XE-65	1	Unaffected
				KE-65	1	Unaffected
				WP-40	1	Unaffected
Sheep	8.0%	3	1	XE-65	1	Affected
				KE-65	1	Died
				WP-40	1	Affected
	4.0%	3	1	XE-65	1	Affected
				KE-65	1	Affected
				WP-40	1	Unaffected

[1] *XE-65* = An emulsion concentrate containing toxaphene 65 per cent, xylene 25 per cent, *Triton X-100* 10 per cent; *KE-65* = A commercially formulated emulsion concentrate containing 65 per cent toxaphene dissolved in kerosene; *WP-40* = A commercially formulated wettable powder containing 40 per cent toxaphene.

dipping in 4.0 per cent toxaphene but recovered and one was unaffected.

The results summarized in table 3 illustrate that adult animals can withstand relatively heavy treatments with toxaphene, whereas the data in table 2 indicate that young calves are much more susceptible. It appears that a concentration of 1.0 per cent toxaphene is close to the minimum single treatment concentration likely to produce toxic symptoms as only one of 11 young calves was affected. The results obtained from applying eight successive treatments at 0.75 per cent concentration indicate that the chemical can be repeatedly applied at a concentration slightly below that likely to produce toxic symptoms without cumulative toxic effects.

GENERAL OBSERVATIONS ON THE TOXICITY OF TOXAPHENE FORMULATIONS.—A comparison of the end results of treatment with the three types of formulations does not show any outstanding difference between formulations. It was noted, however, that whether drenched, sprayed, or dipped, the animals treated with xylene emulsions were usually the first to become affected. Generally, symptoms were noted next with the kerosene emulsion treatments, and the wettable powder treatments were usually last to produce toxic symptoms. One series of tests was made with a toluene emulsion in comparison with the other three formulations and it was found to cause symptoms slightly more rapidly than the xylene emulsion.

Results with Chlordane.—Chlordane, as a 50 per cent wettable powder, was sprayed on one young calf at 8.0 per cent concentration and the animal died in convulsions within 24 hours after treatment. Similar results followed the spraying of a calf with a xylene emulsion of chlordane at 4.0 per cent concentration. Ten calves were sprayed with that emulsion at 2 per cent concentration—4 died and 6 were unaffected. In an incomplete experiment 10 calves were sprayed with 1.0 per cent chlordane and one of the animals died of typical poisoning.

A suckling calf, a 3-month-old kid, and a 3-month-old lamb were treated 8 times at 4-day intervals with 1.5 per cent chlordane, a xylene emulsion being used. All three animals died, the lamb and the kid becoming affected after the third dipping, and the calf after the eighth spraying.

The data on external treatments with chlordane are too few for definite conclusions but indications are that in so far as suckling calves are concenrned, chlordane is of about the same order of toxicity as toxaphene.

Results with Benzene Hexachloride.—

Two pigs were sprayed once with a xylene emulsion concentrate of 95 per cent gamma isomer benzene hexachloride, the material being applied at a concentration of 0.5 per cent gamma isomer. The treatment had no apparent effect. A kid and a lamb, both 3-months-old, were repeatedly dipped at 4-day intervals in that formulation at a concentration of 0.15 per cent gamma isomer. The lamb was affected after two dippings and died after the seventh. The kid was affected during the course of eight dippings but recovered.

Calves were found to be much more susceptible to the gamma isomer of benzene hexachloride. The results of the experiments with suckling calves are given in table 4. In earlier experiments cited in the introduction, it was found that adult cattle suffered no apparent injury from repeated sprayings with 0.15 per cent gamma benzene hexachloride. As a starting point in this series of tests, a calf was sprayed once with that concentration and it died within a few hours. Four calves were sprayed once with 0.10 per cent concentration and all were poisoned, three of the four dying from the treatment. Of 11 calves sprayed once with 0.05 per cent gamma isomer 3 died, 2 were affected but recovered, and 6 were unaffected. Four calves sprayed with 0.025 per cent concentration were apparently unaffected.

Several types of benzene hexachloride were used in these experiments and the results for the different forms are tabulated separately. One benzene hexachloride sample consisted of 12 per cent gamma isomer and 88 per cent other isomers. A second was 36 per cent gamma isomer and a third was 95 per cent gamma isomer. Regardless of the relative proportions of the gamma to the other isomers, the end results appeared dependent upon the gamma isomer concentration. It seems, therefore, that the acute toxicity of benzene hexachloride sprays applied to young calves is almost entirely dependent upon the gamma isomer.[1]

In addition to the experiments cited above, workers at the Kerrville laboratory, in making field tests of insecticides, have sprayed or dipped several hundred suckling calves in gamma benzene hexachloride at concentrations ranging from 0.025 to 0.03 per cent without noting any ill effects among the treated animals.

SYMPTOMATOLOGY AND PATHOLOGY OF CHLORINATED HYDROCARBON INSECTICIDE POISONING.—For all practical purposes the symptoms and lesions shown in poisoning with each of the chlorinated hydrocarbon insecticides observed are the same, resembling in general those first reported for chlordane by Radeleff (1948).

Two distinct groups or phases of symptoms are seen. They may occur singly or follow one another. One group of symptoms could aptly be designated as the phase of nerve stimulation. In such cases there are excessive salivation, grinding of the teeth, rolling of the eyes, muscular twitching, hyperexcitability, and finally convulsions. Any one, or all, of these may occur. The other group of symptoms could be designated as the phase of nerve depression. Animals so affected are dull, listless, fail to eat or drink, and appear blind.

In all instances of poisoning by benzene hexachloride, toxaphene, and chlordane, symptoms were noted in less than 48 hours after application. Some animals

Table 4.—Effects of benzene hexachloride sprays applied to suckling calves.

GAMMA BHC CONCENTRATION	NUMBER TREATED	NUMBER OF TREATMENTS	FORMULATION ADMINISTERED[1]	NUMBER OF ANIMALS	RESULTS
0.15%	1	1	XE-20(95)	1	Died
0.10%	4	1	XE-20(95)	2	2 Died
			WP-6(12)	2	1 Died
					1 Affected
0.05%	11	1	XE-20(95)	2	2 Died
			WP-6(12)	3	1 Affected
					2 Unaffected
			WP-12(36)	3	1 Affected
					2 Unaffected
			WP-12(95)	3	1 Died
					2 Unaffected
0.025%	4	1	XE-20(95)	2	2 Unaffected
			WP-6(12)	2	2 Unaffected

[1] *XE-20(95)* = A xylene emulsion concentrate containing 20 per cent gamma BHC; made from benzene hexachloride consisting of 95 per cent gamma and 5 per cent other isomers.
WP-6(12) = A commercially formulated wettable powder containing 6 per cent gamma BHC; made from benzene hexachloride consisting of 12 per cent gamma and 88 per cent other isomers.
WP-12(36) = A commercially formulated wettable powder containing 12 per cent gamma BHC; made from benzene hexachloride consisting of 36 percent gamma and 64 per cent other isomers.
WP-12(95) = A commercially formulated wettable powder containing 12 per cent gamma BHC; made from benzene hexachloride consisting of 95 per cent gamma and 5 per cent other isomers.

[1] This paper describes tests conducted prior to December 1948. Since that time further work has been done using the pfactically pure gamma isomer of benzene hexachloride. Four 2-weeks-old Hereford calves were not affected by sprays containing 0.1 per cent lindane. Four 2-weeks-old dairy calves were sprayed with 0.05 per cent lindane without ill effect, but of four treated with 0.1 per cent, one died, one was affected, and two were unaffected.

became affected in as little as 2 hours but most of the animals became affected at about the sixth hour after treatment.

Death, regardless of the symptoms preceding it, is one of agony. The body assumes a position of opisthotonos. There is usually an accumulation of saliva on the lips and often on the ground. The agonal paddling movements of the animal leave a distinct mark upon any reasonably soft ground. At time of death the body temperature usually is in excess of 110° F.

The carcass is cyanotic. Hemorrhages are common in the gastro-intestinal tract, heart, and lungs. The lungs are usually congested; often purple in color. The liver and kidneys do not usually show distinctive changes. Swelling and congestion are the most obvious. The brain and spinal cord are usually congested; in some cases there is also edema.

Micropathological lesions involve, with wide variations, fatty changes of the liver and kidneys, congestion of the lungs, kidneys, liver, brain, and spinal cord. Edema and neuron changes are found in the brain and spinal cord.

DISCUSSION.—Investigations of the toxicity of insecticides to livestock conducted thus far have been to measure the effects of the various materials from the standpoint of acute or subacute toxicity. No long-term chronic studies have been undertaken.

It appears from the results described above that there is little danger of acute poisoning of livestock through normal field use of DDT, methoxychlor, and TDE as insecticides. The danger that exists is perhaps most likely to be caused by the solvents or other accessory materials used in formulating the insecticides. It is apparent that there are hazards connected with the use of chlordane, toxaphene, and benzene hexachloride.

It is unfortunate that the three first-mentioned insecticides which seem relatively safe are comparatively poor treatments against ticks since they are relatively ineffective against engorged ticks. All three of the most toxic insecticides are more effective against ticks. Chlordane and toxaphene need to be used at a concentration of 0.5 per cent to kill such resistant forms as certain engorged female ticks. Gamma benzene hexachloride lacks residual effects but is effective in destroying ticks on the host at a concentration of 0.025 per cent. The results with emulsions and a wettable powder of toxaphene, with an emulsion of chlordane, and with an emulsion and wettable powders of benzene hexachloride indicate that they may be used with safety at the minimum concentrations effective for tick control but that the ratio between insecticidal dose and toxic dose is not as great as might be desired. The results obtained with the limited numbers of animals used in these experiments indicate that, when applied to calves, toxaphene, chlordane, and gamma benzene hexachloride may cause poisoning at twice the concentrations needed for controlling certain ticks.

It is difficult to recommend insecticides for general public use when the margin of safety between insecticidal concentration and the concentration toxic to animals is in the neighborhood of only 2 to 1. Any factor which will increase the concentration of the insecticide in a spray or dip will be potentially dangerous to the animals treated. Years ago, livestock producers learned to use extreme care in tick control, when employing arsenical dips which had to be applied at concentrations close to the toxic level. In recent years, stockmen working with relatively safe materials such as DDT have tended to become careless in the application of insecticides.

It is well to emphasize factors that might result in dangerously high concentrations being applied to livestock. A common error is misjudging the amount of water used for diluting the insecticide through merely guessing at the volume in a spray tank or dipping vat. Frequently emulsion concentrates are improperly dispersed in water. This may be due to improper packaging of the concentrate so that its decomposition is hastened by such catalytic agents as rusty containers. Improper storage at high temperatures sometimes accelerates such decomposition. Frequently manufacturers prepare emulsion concentrates which work well in their local water but do not emulsify properly in extremely hard or very acid waters. Agents incompatible with such waters are sometimes used in formulating wettable powders. Frequently stockmen fail to stir, mix, or agitate sufficiently in preparing sprays and dips.

In view of accidents that frequently occur and the selective toxic action of

benzene hexachloride, toxaphene, and chlordane to young livestock, these three insecticides must be considered dangerous and should be used with extreme care, especially on young calves.

SUMMARY.—Sprays and dips of new chlorinated hydrocarbon insecticides have been tested for acute toxicity to livestock. Applied to calves at concentrations as high as 8.0 per cent DDT, TDE, and methoxychlor caused no symptoms of insecticide poisoning. Suckling calves were found to be particularly susceptible to benzene hexachloride, toxaphene, and chlordane. It was indicated that young calves might be poisoned when those insecticides are employed at twice the concentrations necessary for tick control. Factors that might result in accidental poisoning of livestock through field use of insecticides are cited and it is suggested that the three last named insecticides be used with extreme care, especially on suckling calves.

LITERATURE CITED

Bushland, R. C., R. W. Wells, and R. D. Radeleff. 1948. The effects upon livestock of dips and sprays containing new chlorinated insecticides. JOUR. ECON. ENT. (In press.)

Radeleff, R. D. 1948. Chlordane poisoning: symptomatology and pathology. Vet. Med. **43**(8): 342–7.

Control of Corn Earworm on Sweet Corn in Northern California

OSCAR G. BACON[1,2]

The corn earworm, *Heliothis armigera* Hbn., is the most serious insect pest attacking sweet corn in Northern California. Research by other workers has shown that it can be controlled by timely applications of a mineral oil-pyrethrum mixture or a mineral oil-DDT mixture. These applications are made by using a plunger type oil can to inject approximately one-half cubic centimeter of the material into the tip of each ear. While this treatment is the most effective known, there are certain disadvantages. The procedure is laborious and time-consuming. Furthermore, where large acreages are involved, it is often impossible to apply the treatment at the most critical time to insure best control. Where growth of the corn is uneven, treated ears must be marked and a second application made to treat the ears that were not in the proper state of development at the time of the first application. If the applicators are not in proper adjustment, too little or too much insecticide may be applied. Applying an excess of the mixture or applying the material before pollination is complete prevents fertilization and development of the kernels with consequent excessive "nubbing" of the ears.

Because of the numerous objections to the oiling method, work was undertaken during the years 1948 and 1949 to study the possibilities of simplifying control by using new insecticides and by improving methods of application. A large number of insecticides were tested as dusts and aerosols in 1948. In 1949 dusts and aerosols were further studied and in addition sprays were investigated.

1948 EXPERIMENTS.—Investigations involving dust applications of DDT and DDD revealed that under conditions of low infestation and with proper timing, fair control of the corn earworm could be obtained. It was evident, however, that at least two applications of a 10 per cent dust, each at the rate of 35 to 40 pounds per acre, were necessary. These treatments resulted in from 50 to 60 per cent control.

Tests with aerosol applications of 2 per cent emulsions of DDT also looked promising when applied with a small knapsack aerosol gun at rates of 7 to 8 gallons per acre per application. Two applications resulted in approximately 65 per cent con-

[1] Junior Entomologist, University of California, Berkeley.

[2] Dr. W. J. Virgin, Plant Pathologist and Mr. George Oba, Assistant Plant Pathologist, California Packing Corporation, Seed Department, Sunnyvale, California gave their full cooperation in the conduct of this investigation. They aided in every phase of the work and deserve full credit for assistance in planning and carrying out the various experiments.

Thanks are due to Oliver Fullmer, Wallace Erwin and James Witt for determining the DDT residues in the various treatments.

Table 1.—Rates of application and control obtained with various concentrations of DDT applied as sprays, aerosols and dust.

Materials to Make 100 Gallons of Spray	Amount Applied per Acre			Toxicant per Acre, Pounds	Effectiveness of Treatments Roasting Ear Stage, Aug. 16			DDT Residue PPM,[4] Aug. 16	
	First July 22	Second July 27	Third Aug. 1		Per Cent Infested Ears	Per Cent Clean Ears	Per Cent under Check	Husks and Silks	Ears
Check	—	—	—	—	88.0	12.0	—	5.0	0
Sprays; Applications in Gallons per Acre									
25% DDT Emuls. Conc. 3 Gals.+10 Gals. Mineral Oil[1]	16.40	23.02	49.34	5.32	37.0	63.0	58.0	53.0	0
3 Gals+10 Gals. Mineral Oil	41.05	49.34	49.34	8.38	17.0	83.0	80.7	43.0	0
1.5 Gals.+5 Gals. Mineral Oil	54.73	49.34	52.63	4.69	29.0	71.0	67.1	28.0	0
1.5 Gals.+4.9 lbs. 85% Emulsifier[2]+1 Gal. Mineral Oil	—	49.34	42.76	2.76	19.0	81.0	78.4	20.0	0
4% DDT Solution 2.8 Qts.+4 lbs. 100% Emulsifier[2]+1 Gal. Mineral Oil	49.34	49.34	49.34	4.44	21.0	79.0	76.1	—	—
	54.73	49.34	49.34	4.60	10.0	90.0	88.6	25.0	0
2.8 Qts.+2 Qts. Emulsifier[5] +1 Gal. Mineral Oil	54.73	49.34	49.34	4.60	20.0	80.0	77.3	41.0	0
Aerosol; Applications in Gallons per Acre									
2% DDT Emulsion[3]	18.72	18.72	6.73	7.08	72.0	28.0	18.2	32	0
Dust; Applications in Pounds per Acre									
10% DDT	50.00	50.00	50.00	15.00	81.5	18.5	7.4	12	0

[1] The oil in all treatments was a highly refined white mineral oil with a minimum UR of 96 and 77 seconds Saybolt Viscosity.
[2] Di octyl sodium sulfosuccinate. (*Vatsol OT*).
[3] Emulsifying agent, Triton X-100.
[4] Determined by the Schechter-Haller Method.
[5] *Ortho No. 5.*

trol while 3 resulted in 75 per cent control. However, these aerosol applications more nearly approached those of a spray treatment rather than a true aerosol.

1949 EXPERIMENTS.—Dust and aerosol treatments were further investigated and because of promising results reported by Wene & Blanchard (1949) and Blanchard, *et al.* (1949) where DDT-oil emulsion sprays were used, emphasis was placed on a study of sprays incorporating mineral oil and wetting agents.

EXPERIMENT IN CENTRAL SAN JOAQUIN VALLEY.—Investigations were conducted on Country Gentleman variety sweet corn being grown for seed. The experiments were of a preliminary nature and were designed to compare the efficiency of various spray formulations of DDT with aerosol applications of a 2 per cent DDT emulsion and commercial applications of a 10 per cent DDT dust. Seven non-replicated spray treatments were each applied to single row plots 100 feet long located in one corner of a 5-acre field. Across the inner end of these seven rows a block 20 feet long was left untreated as a check. The aerosol treatment was applied to a block seven rows wide which extended beyond the check for 50 feet. The remainder of the field was treated with the 10 per cent DDT dust.

The sprays were applied with a small knapsack sprayer. The aerosol was applied with a knapsack gun[1] and the dust was applied with a large high clearance, six row power duster.

Prior to treatment, this field was being heavily attacked by larvae of the corn earworm. Considerable feeding was observed in the tassels before they were open. A survey made on July 6 revealed an average of 47 per cent of the tassels were infested. The larvae were so abundant that feeding was also observed on the leaves and stalks and many of the young ears were invaded before any silks had started to show.

Surveys made on July 12, 21 and 25 revealed averages of 67 per cent, 57 per cent and 36 per cent, respectively, of the silk masses then showing, to have eggs present. On July 25 an average of 56 per cent of the ears had small worms present or showed evidence of worm injury. This would tend to indicate that the first applications which were made on July 22 were applied too late to insure maximum control.

The formulation of the materials and rates of application of the various treatments are given in table 1. The source of

[1] Model of the Banta and Driscoll Hi-Fog.

DDT in treatments 1 to 4 was a commercially prepared 25 per cent DDT emulsifiable concentrate. The 44 per cent DDT solution used in treatments 5 and 6 was made by dissolving technical DDT in a solvent.[1] In formulating the sprays, the oil, insecticide and emulsifying agent were thoroughly mixed and then added to the necessary amount of water to make the desired quantity of emulsion spray. Considerable stirring with a motor driven propeller prior to the application of the dilute sprays was necessary to produce a desirable emulsion where the higher concentrations of mineral oil were used.

The results obtained are also given in table 1. It is evident from the data presented that the spray treatments were much more effective in controlling the corn earworm than were either the dust or the aerosol applications. The various spray treatments resulted in from 63 to 90 per cent clean ears; the aerosol treatment, 28 per cent and the dust only 18.5 per cent as compared with 12 per cent in the check. In the spray treatments where the wetting agent di octyl sodium sulfosuccinate[2] was used, rather severe injury was observed at the base of the leaves and ears. Large discolored areas were visible which had the apperance of water soaked or oil soaked tissue. The portion of the leaf away from the stem and the upper and external portions of the husks showed little injury but the inner husks near the ear showed signs of damage. Apparently the spray mixture collected in these places which served as natural traps and the injury probably resulted from prolonged exposure to the liquid due to slow evaporation. While there was no apparent injury to the kernels of the ear, burns on the husks would present a very objectionable appearance when marketed.

It should be borne in mind, however, that this wetting agent was used at a concentration of 0.5 per cent which was extremely high and greatly exceeded that recommended by the manufacturer. In preliminary laboratory tests it appeared that from 0.5 to 1 per cent solutions of this material were necessary to insure complete wetting and penetration of the silk mass. For this reason the 0.5 concentration was used in field experiments. It may be, that under conditions of actual practice in the field, much lower concentrations would wet sufficiently to give satisfactory control of the corn earworm and yet not burn or injure the plant tissue.

EXPERIMENTS IN SANTA CLARA VALLEY.—The experiments in the Santa Clara Valley were conducted on Golden Cross variety sweet corn also being grown for seed. The investigation was divided into two experimental series.

In the first, sprays of DDT, lindane, pyrenone, aldrin and dieldrin and methoxychlor were studied.

In the second, dusts of DDT, 497 and 118 were compared with aerosol applications of these same materials.

Because the oil injection treatment is the most effective so far developed, this treatment was included in both series for comparison.

EXPERIMENTAL METHODS.—*Plot Arrangement.*—In the first series the treatments were applied to small plots 3 rows wide and 50 feet long. Each treatment was replicated twice in a randomized experiment.

In the second series the dusts and aerosol applications were made on plots six rows wide and because of the shape of the field varied in length from 390 feet to 785 feet. These treatments were also replicated twice in a randomized experiment.

The 1 per cent DDT in oil individual ear injection treatment was not replicated in this series and was applied to a plot 6 rows wide and 50 feet long.

Equipment.—The sprays were all applied with a knapsack hand sprayer.

The dusts in the second experiment were applied by means of a specially constructed high clearance, six-row power duster having three nozzles per row arranged so that one was located directly over the top of the plant and one on each side directed toward the ear level.

The aerosols were applied by means of a specially built, six-row power aerosol machine. The main mechanism consisted of a small, compact spray pump powered by an engine driven hydraulic power pack. The machine was operated at a pressure of approximately 750 pounds per square inch. Four nozzles with extremely small openings (0.020 inch) were provided for each row, two on each side. The nozzles were directed toward the ear level of the plant at a 45 degree angle from above and below. The entire aerosol unit was mounted on the back of the specially built

[1] *Velsicol A R 60.*
Vatsol OT.

power duster for propulsion through the field.

The ear injection treatments were made with a small plunger type oil can in which the plunger lever was fitted with a stop so that when pressed with the thumb approximately 0.37 cubic centimeter of the oil-insecticide mixture was injected into the tip of the ear.

Sampling Methods.—Trends of infestation in the developing ears were followed during the growth of the crop. At roasting ear stage the degree of infestation was determined by cutting off a portion of the ear just above the tip of the cob and noting whether the silk channel had been penetrated. This could be easily observed because as the small larvae work their way down through the silk, they leave a fine line of frass which is clearly recognizable. Where it was evident that the larvae had penetrated the ear, the husk was pulled away to determine the extent of injury. Infested ears were divided into two categories, light and heavy. The light category comprised those ears in which the larvae had not yet reached the ear proper or had inflicted only a very small amount of damage to the tip that in no case extended more than a half-inch down the ear. The heavy category comprised those ears which were seriously injured and in all cases the feeding extended below a half-inch on the ear from the tip

Table 2.—Formulations and rates of application of various insecticides applied as sprays.

Materials to Make 100 Gallons of Spray	Amount Applied per Acre, Gallons				Actual Toxicant per Acre Pounds
	1st Aug. 9	2nd Date	2nd Amount	3rd Aug. 18	
Check	—	—	—	—	—
1% DDT in oil[3]	0.375 cc injected in each ear				
25% DDT Emulsifiable Concentrate:					
3 Gals+10 Gals. Mineral Oil[4]	34.25	8/12	30.34	25.35	5.45
3 Gals.+10 Gals. Mineral Oil	48.64	8/12	51.75	46.23	8.80
1.5 Gals.+5 Gals. Mineral Oil	57.59	8.12	57.24	53.82	5.06
1.5 Gals.+4.9 lbs. 85% Emulsifier[5]	50.70	8/19	50.70	—	3.04
44% DDT Solution:[2]					
3 Qts.+4.9 lbs. 85% Emulsifier[5]	50.70	8/12	51.41	52.76	4.65
3 Qts.+2 Qts. Emulsifier[6]	50.70	8/12	55.83	50.05	4.70
20% Lindane Emulsifiable Concentrate:					
2.5 Qts.	60.18	8/12	50.70	49.39	1.60
2.5 Qts.+4.9 lbs. 85% Emulsifier[5]	58.95	8/19	49.34	—	1.08
25% Lindane Wettable Powder:					
4 lbs.	52.76	8/12	52.41	47.98	1.53
Pyrenone Spray:[7]					
1 Gal.[1]	54.83	8/12	47.63	50.05	0.074
1 Gal.[1]+4.9 lbs. 85% Emulsifier[5]	53.12	8/19	50.70	—	0.056
25% 497 Emulsifiable Concentrate:					
2 Qts.	54.83	8/12	50.70	44.87	1.51
2 Qts.+4.9 lbs. 85% Emulsifier[5]	56.19	8/19	50.70	—	1.07
25% 118 Emulsifiable Concentrate:					
1 Gal.	54.52	8/12	50.70	52.41	3.15
1 Gal.+4.9 lbs. 85% Emulsifier[5]	51.41	8/19	50.70	—	2.04
25% Methoxychlor Emulsifiable Concentrate:					
3 Gal.	54.12	8/12	49.34	53.47	9.42
3 Gal.+4.9 lbs. 85% Emulsifier[5]	52.06	8/19	50.70	—	6.17

[1] 2 Gallons were used for the first application, Aug. 9.
[2] Solvent, *Velsicol AR-60*.
[3] Standard No. 9 white mineral oil; applied Aug. 16.
[4] The oil used in all treatments was a highly refined white mineral oil with a minimum UR of 96 and 77 seconds Saybolt viscosity.
[5] *Vatsol OT*.
[6] *Ortho No. 5*.
[7] *Ortho 63*.

INSECTICIDES USED IN TESTS.—*Sprays.*—DDT was used in emulsions and in solutions in combination with a white mineral oil having a minimum UR of 96 and a viscosity of 77 seconds Saybolt and with and without wetting agents.

Lindane used as emulsions with and without wetting agent and as a wettable powder.

Pyrenone, an emulsifiable material of the following formula:

Pyrethrins	0.53 per cent
Technical piperonyl butoxyde	10.70 "
Petroleum oil	78.27 "
Polyethylene glycol	10.50 "

This was used both with and without wetting agent.

Dieldrin was used as an emulsion both with and without additional wetting agent.

Aldrin was used as an emulsion both with and without additional wetting agent.

Methoxychlor, dianysil trichloroethane, used as an emulsion with and without additional wetting agent.

The complete formulation of the sprays, dates of application and rates of application appear in table 2.

Dusts:

1. Lindane
2. DDT
3. Dieldrin
4. Aldrin

The concentrations of the above insecticides in the dust treatments in which they were used, with the exception of lindane are given in table 4.

Aerosols:

1. DDT
2. Dieldrin
3. Aldrin

The formulation of the above materials and the concentrations at which they were used in the several aerosol treatments are shown in table 5.

Timing of Applications.—At the time the first spray applications were made on August 9, approximately 25 to 30 per cent of the ears were in silk. On August 12, at the time of the second application, from 50 to 60 per cent of the ears were in silk and on August 18 and 19, when the last applications were made, approximately 100 per cent of the ears had silked.

The dust and aerosol treatments were not so well timed. Approximately 40 to 50 per cent of the ears were in silk when the first applications were made on August 23 and 24; this increased to approximately 65 per cent on August 26 and 27 when the second applications were made. Due to rains and an irrigation, the third application was greatly delayed and could not be applied until September 9 when all the ears were in silk.

RESULTS OBTAINED WITH THE VARIOUS TREATMENTS.—*Sprays.*—The results obtained with the sprays are shown in table 3. From the data presented it is evident that of all the insecticides tested, DDT resulted in the best control. Of these, the individual ear injection treatment resulted in 99.5 per cent clean ears. The number of clean ears with the various sprays ranged from 88 to 97 per cent and the control obtained was slightly better where DDT was used in combination with mineral oil. All these treatments showed a marked reduction when compared with the check which averaged 32.5 per cent clean ears. The only other insecticide that approached what might be considered satisfactory control was lindane and this only occurred when used as an emulsion spray with the wetting agent.

DDT Residues.—Residue analyses were made on samples of corn from all spray and dust treatments where DDT was used. A random sample of 10 ears was picked from each treatment at roasting ear stage. Five ears were selected from each 10 ear sample for analysis. The samples were divided into two parts, the husks and silks and the husked, untrimmed ears. Analyses were made of each using the Schechter-Haller method. The data for the samples from the San Joaquin Valley experiment appears in table 1 and for the Santa Clara Valley experiment in table 3.

It will be noted in every case, including the checks, that considerable amounts of DDT were present on the husks and silks but with the exception of the individual ear injection treatment, little or none was found on the edible portion of the ears. No analyses were made on trimmed ears but it is believed that where DDT was present on the ear, it was at the very tip and had the ears been trimmed, as is the practice for market corn, in all probability no DDT would have been found. Because the checks were surrounded by DDT treatments, the residues found on them were undoubtedly due to dust and spray drifts.

Table 3.—Controls and DDT residues resulting from application of various spray treatments.

Materials to Make 100 Gallons of Spray	Effectiveness of Treatments. Roasting Ear Stage, Sept. 6, 1949				DDT Residue PPM[1] Sept. 7, 1949	
	Per Cent Infested Ears		Per Cent Clean Ears	Per Cent Under Check	Husks and Silks	Ears
	Light	Heavy				
Check	5	62.5	32.5	00.0	1.4	0.00
1% DDT in Oil Individual Ear Injection	0	00.5	99.5	99.3	17	2.10
25% DDT Emulsifiable Concentrate:						
3 Gals.+10 Gals. Mineral Oil	1	2	97.0	95.6	28	0.00
3 Gals.+10 Gals. Mineral Oil	0.5	2.5	97.0	95.6	120	0.63
1.5 Gals.+5 Gals. Mineral Oil	1	6	93.0	89.6	40	0.00
1.5 Gals.+4.9 lbs. 85% Emulsifier[2]	0	5	95.0	92.6	45	0.17
44% DDT Solution:						
3 Qts.+4.9 Lbs. 85% Emulsifier[2]	2	2	96.0	94.1	26	0.00
3 Qts.+2 Qts. Emulsifier[3]	3	9	88.0	82.2	16	0.00
20% Lindane Emulsifiable Conentrate:						
2½ Qts.	7.5	47.5	45.0	18.5	—	—
2½ Qts.+4.9 Lbs. 85% Emulsifier[2]	6	23	71.0	57.0	—	—
25% Lindane Wettable Powder:						
4 Lbs.	5	58.5	36.5	5.9	—	—
Pyrenone:[4]						
1 Gal.	10.5	37	52.5	29.6	—	—
1 Gal.+4.9 Lbs. 85% Emulsifier[2]	3.5	46.5	50	25.9	—	—
25% 497 Emulsifiable Concentrate:						
2 Qts.	6.5	37	56.5	35.6	—	—
2 Qts.+4.9 Lbs. 85% Emulsifier[2]	3.5	35	64.5	43.0	—	—
25% 118 Emulsifiable Concentrate:						
1 Gal.	11	33.5	55.5	34.1	—	—
1 Gal.+4.9 Lbs. 85% Emulsifier[2]	3.5	45	51.5	28.2	—	—
25% Methoxychlor Emulsifiable Concentrate:						
3 Gal.	6	33	61.0	42.2	—	—
3 Gal.+4.9 Lbs. 85% Emulsifier[2]	7	39	54.0	31.9	—	—

[1] Determined by the Schechter-Haller Method.
[2] *Vatsol OT.*
[3] *Ortho No. 5.*
[4] *Ortho 65.*

Dusts.—The results obtained with dust treatments are given in table 4. As with the sprays, DDT resulted in the best control but the results were far inferior to those obtained with the sprays or the individual ear injection treatment. Four applications of a 10 per cent dust resulted in 71.5 per cent worm-free ears. This is in comparison to 7.7 per cent in the check. In another experiment where a 10 per cent dust was used, three applications resulted in 82 per cent worm-free ears; however, in this case 32.5 per cent of the ears in the check were clean.

The results of these experiments tend to substantiate previous investigations in that dust treatments proved satisfactory where the infestations of corn earworm were relatively light. As in 1948, a 10 per cent DDT dust proved to be more effective than a 5 per cent dust.

Two and one-half per cent dusts of compounds dieldrin and aldrin were ineffective. In every case a fourth application resulted in slightly better control than three but the differences are probably not significant.

In another experiment conducted in conjunction with the spray experiment, 1 per cent lindane dust was used in 3 and 4 applications at the rate of 50 pounds per acre per application. The control obtained was not satisfactory. Three applications resulted in 45 per cent clean ears while

Table 4.—Rates of application and control obtained with various concentrations of DDT and compounds 497 and 118 applied as dusts.

Treatment	Amount Applied per Acre, Pounds				Actual Toxic Material per Acre Total Pounds	Effectiveness of Treatments. Roasting Ear Stage, Sept. 22, 1949			
	1st Aug. 23	2nd Aug. 26	3rd Sept. 9	4th Sept. 13		Per Cent Infested Ears		Per Cent Clean Ears	Per Cent Under Check
						Light	Heavy		
Check	—	—	—	—	—	5.0	87.3	7.7	—
1% DDT in oil	0.335 cc. Injected in Each Ear				—	0.0	3.0	97.0	96.7
10% DDT	39.73	32.78	32.71	—	10.52	0.5	38.0	61.5	58.3
	39.73	32.78	32.71	33.23	13.84	3.5	25.0	71.5	69.1
5% DDT	26.99	34.50	35.08	—	4.83	7.5	44.0	48.5	44.2
	26.99	34.50	35.08	33.78	6.52	3.0	48.0	49.0	44.7
5%DDT+ 2% Oil	37.09	36.94	34.95	—	5.45	6.0	53.0	41.0	36.1
	37.09	36.94	34.95	34.92	7.20	8.0	50.0	42.0	37.2
2½% 497	33.84	34.84	34.96	—	2.59	5.5	75.0	19.5	12.8
	33.84	34.84	34.96	41.88	3.64	9.0	67.0	24.0	17.7
2½% 118	34.85	32.84	31.39	—	2.48	9.0	79.5	11.5	4.1
	34.85	32.84	31.39	31.08	3.25	9.5	74.0	16.5	9.5

four resulted in 49 per cent. These figures are in comparison to 32.5 per cent clean ears in the check.

Aerosols.—The results obtained with the various aerosol treatments are given in table 5.

As with the sprays and dusts, DDT resulted in the greatest control. It is interesting to note that the 1 per cent DDT in oil aerosol was superior to a 2 per cent DDT emulsion and was almost as good as the 10 per cent DDT dust (Table 4). In

Table 5.—Rates of application and control obtained with various concentrations of DDT and compounds 497 and 118 applied as aerosols.

Treatment	Amount Applied per Acre, Gallons				Actual Toxic Material per Acre, Total Pounds	Effectiveness of Treatments. Roasting Ear Stage, Sept. 22, 1949			
	1st Aug. 24	2nd Aug. 27	3rd Sept. 9	4th Sept. 13		Per Cent Infested Ears		Per Cent Clean Ears	Per Cent Under Check
						Light	Heavy		
Check	—	—	—	—	—	5.0	87.3	7.7	—
1% DDT in Oil[1]	0.335 cc. Injected in Each Ear					0.0	3.0	97.0	96.7
1% DDT in Oil[2]	10.56	9.36	10.35	—	2.08	6.5	37.5	56.0	52.3
	10.56	9.36	10.35	9.29	2.72	8.0	44.0	48.0	43.7
2% DDT Emulsion	8.95	11.28	9.17	—	4.71	11.0	59.0	30.0	24.2
	8.95	11.28	9.17	9.64	6.25	9.5	60.5	30.0	24.2
2% 497 Emulsion	9.29	10.15	9.76	—	4.67	7.5	77.5	15.0	7.9
	9.29	10.15	9.76	9.25	6.15	9.0	78.5	12.5	5.2
2% 118 Emulsion	9.90	9.67	9.77	—	4.69	6.0	84.0	10.0	2.5
	9.90	9.67	9.77	8.33	6.02	13.5	80.0	6.5	0.0

[1] Standard No. 9 White Mineral Oil.
[2] The oil used consisted of a blend composed of 50 per cent Standard No. 3 White Mineral Oil and 50 per cent highly refined kerosene (Eocene oil).

general, the results obtained with aerosols were not satisfactory.

SUMMARY AND CONCLUSIONS.—Results have shown that of many insecticides tested DDT is the most effective for controlling the corn earworm on sweet corn. In order to insure satisfactory control it is necessary that the insecticide impregnate the silk mass and penetrate the silk channel to form a barrier. Two to three applications of emulsion sprays containing 6 pounds of actual DDT and 5 to 10 per cent mineral oil or suitable wetting agents per 100 gallons of spray have been shown to adequately perform the function of wetting and penetrating the silk mass with consequent satisfactory control of the corn earworm. When properly timed and applied they have resulted in control that approached that obtained with the individual ear oiling method.

Where low populations of corn earworm are encountered, dust treatments of DDT may result in from 60 to 70 per cent control. Where large populations are involved, dusts have not proved effective and in no case have been shown to be as satisfactory as sprays or individual ear injections. With dust treatments a light deposit of insecticide occurs on the outside of the silk mass with the inside remaining relatively free of insecticide. Larvae getting through this thin barrier are free to penetrate and infest the ears.

Aerosol applications have proved to be less effective than either sprays or dusts. Presumably insufficient insecticide is deposited in the silk mass by this method of application to prevent entry of the corn earworm larvae.

Where DDT has been used, residue analyses have shown rather large amounts to be present on the husks and silks of the harvested ears. Small amounts or no DDT was found on the edible portion of the ear. The greatest amount of residue noted was 2.10 ppm on ears treated with 1 per cent DDT in oil by the injection method. While not definitely determined it is believed that this could be removed by trimming.

Plants treated with DDT sprays and dusts should not be fed to dairy cattle producing milk or to livestock that is being fattened for early sale as meat animals because of the large insecticide residues present on the stalks and foliage.

LITERATURE

Wene, George P. and R. A. Blanchard. 1949. Control of the corn earworm on sweet corn in the Lower Rio Grande Valley. Texas Agr. Expt. Sta. Progress Rept. **1154**.

Blanchard R. A., W. A. Douglas, and G. P. Wene. 1949. DDT sprays for control of the corn earworm and budworm in sweet corn. U. S. Dept. Agr. **E-780.**

Piperonyl Butoxide and Pyrethrins to Control Rice Weevils[1]

CARL N. WATTS and FRANCIS D. BERLIN, *Research and Development Laboratories, U. S. Industrial Chemicals, Inc.*

The rice weevil, *Sitophilus oryze* L., has long been recognized as the most destructive insect that infests bulk-stored grain (Cotton 1941). This insect not only causes untold damage by its own action but, in so doing, also provides food and conditions that are suitable to the introduction and development of other grain-infesting insects.

Numerous control measures have been employed against this insect in the past with varying degrees of success. Of recent importance is the study in progress by V. A. Beckley (1948). In preliminary tests pyrethrum powders used alone or diluted with diatomaceous earth gave approximately eight months' protection of bagged maize and wheat exposed to natural infestation. These results are remarkable in showing the longevity of protection that may be attained by the use of a pyrethrum dust.

While this preliminary study is of great interest, any large-scale development program based on the use of such a dust would be seriously impaired by the limited supply of pyrethrum that could be allocated for this use.

For this reason, considerable interest

Paid Paper.

[1] Presented at the annual meeting of the Eastern Branch of the American Association of Economic Entomologists at Baltimore, Maryland, November 21–22, 1949.

has been aroused in the use of piperonyl butoxide (Wachs 1947) as an extender of pyrethrins available for this purpose. Piperonyl butoxide and pyrethrins have proven safe and highly effective against a variety of insects in sprays, aerosols, and dusts. Dove (1947) and Cotton (1949) have shown that combinations of piperonyl butoxide and pyrethrins are extremely efficient as sprays in boxcars for grain-insect control.

In view of the efficiency shown by these combinations in related fields, tests were initiated to determine the degree of synergism obtained by the addition of piperonyl butoxide to reduced amounts of pyrethrins. Comparative tests of pyrethrins alone, piperonyl butoxide alone, and four ratios of the two materials prepared in dust form were made in the laboratory on whole-grain wheat.

METHODS AND MATERIALS.—Throughout the test period the laboratory temperature was maintained at from 78–82° F., while the relative humidity was 48–50 per cent. The whole-grain, soft, winter wheat used for these tests had a moisture content of from 11.83 to 12.98 per cent and a dry-ash content of from 1.98 to 2.14 per cent.

The dusts employed in making the comparison between the combinations of piperonyl butoxide and pyrethrins and the materials alone were prepared by impregnating directly the active ingredients on an organic carrier previously proven to be biologically inert to grain insects.

Combinations of piperonyl butoxide and pyrethrins were tested at four ratios; namely, 5–1, 10–1, 13.3–1, and 20–1. Each ratio was tested at two or more rates of application, and each treatment was replicated four times.

These tests were conducted on 200-gram samples of wheat contained in pint, mason-type, glass jars fitted with 35-mesh, wire-screen tops. Treatment of the grain was made at the rate of 0.357 grams of insecticidal dust per 200-gram sample, which is the equivalent of approximately 100 pounds of dust per 1000 bushels of grain.

Immediately after the dust was added, the jar was sealed and turned end for end for one hour on a standard ball mill. This agitation insured thorough distribution of the dust throughout the grain. On completion of the mixing, the jar was unsealed and 100 rice weevils were introduced. The jar was then covered with the screened top and allowed to remain undisturbed until the first examination. For observation the insects were removed from the grain by gently shaking the whole sample over an 8-mesh, galvanized-screen sieve, which was five enough to retain all but the broken kernels, but was coarse enough to allow the insects to pass into an enamel pan for examination.

Table 1.—Laboratory tests comparing effectiveness of dusts containing piperonyl butoxide alone, pyrethrins alone, and combinations of piperonyl butoxide with pyrethrins against the rice weevil.

PER CENT CONCENTRATION OF ACTIVE INGREDIENTS			PER CENT MORTALITY IN	
Piperonyl Buxotide	Pyrethrins	RATIO	7 Days	30 Days
0.80	None	—	10	11
1.20	None	—	11	21
None	0.20	—	49	79
None	.40	—	78	94
None	.80	—	95	99
0.25	.05		79	92
.40	.08	5 to 1	100	100
.60	.12		100	100
.40	.04		86	93
.60	.06	10 to 1	94	99
.80	.08		99	100
.50	.0375	13.3 to 1	88	96
.70	.0525		96	99
.60	.03	20 to 1	74	96
.80	.04		91	99
Control	Untreated		10	17

The first examination of each sample was made seven days after infestation; the second, and final one, was made thirty days after initiation of the tests. In making the examination for insect mortality, extreme care was taken to examine each insect closely to determine whether it was dead or simply inactive. When disturbed, these insects have a habit of simulating death, and unless this habit is carefully taken into consideration, it may easily produce errors in the evaluation of results. At the completion of each examination, the insects were returned to the grain and the whole sample replaced in the test jar.

RESULTS.—The results of these tests are given in table 1. Piperonyl butoxide used alone in a dust was ineffective.

Pyrethrins alone were moderately efficient at the extreme-dose levels employed. However, dusts with only small proportions of pyrethrins combined with piperonyl butoxide were remarkably effective. As an illustration, a dust containing 0.4 per cent pyrethrins alone gave 78 per cent mortality of weevils in seven days, whereas one containing 0.4 per cent piperonyl butoxide and 0.04 per cent pyrethrins (one-tenth of the pyrethrins used alone) gave a mortality of 86 per cent over the same period, thus indicating a remarkable degree of synergism.

A further illustration is provided by the dust containing 0.8 per cent pyrethrins alone, which gave a 95 per cent mortality in seven days, and one containing 0.8 per cent piperonyl butoxide with 0.04 per cent pyrethrins (one-twentieth of the pyrethrins used alone), which gave 91 per cent mortality. Additional evidence of synergism is found in combinations of these two materials used at the 13.3–1 and 5–1 ratios. These results emphasize the fact that synergism between piperonyl butoxide and pyrethrins against rice weevils is operative over a wide range of ratios of these two materials.

Past experience in connection with other work has brought out the fact that an empirical figure based on "total concentration" can be applied to evaluate ratios of piperonyl butoxide and pyrethrins. To arrive at this figure, the concentration of pyrethrins is multiplied by ten and the result is added to the concentration of piperonyl butoxide. Within reasonable limits it has been found that this "total concentration" is approximately proportional to the effectiveness of the combination. As noted in table 1, approximately equal mortalities resulted with the 0.4 per cent piperonyl butoxide and 0.08 per cent pyrethrins dust (5–1 ratio); with the 0.6 per cent piperonyl butoxide and 0.06 per cent pyrethrins dust (10–1 ratio); with the 0.7 per cent piperonyl butoxide and 0.0525 per cent pyrethrins dust (13.3–1 ratio); and with the 0.8 per cent piperonyl butoxide and 0.04 per cent pyrethrins dust (20–1 ratio). It will be seen that all of these dusts contain the same "total concentration" of active ingredients when the empirical calculation shown above is used.

SUMMARY AND CONCLUSIONS.—Small-scale laboratory tests against the rice weevil *Sitophilus oryzae* L. in wheat were conducted with piperonyl butoxide alone, pyrethrins alone, and with combinations of these two materials in dusts to determine the degree of synergism between pyrethrins and piperonyl butoxide.

Piperonyl butoxide used alone at the dosages listed was almost completely ineffective against the rice weevil. Pyrethrins alone at dosages from ten to twenty times those used in the combinations gave from moderate to good control.

Combinations of the two materials in four different ratios gave from good to complete control over the 30-day test period.

An empirical method for calculating "total concentration" is described. Dusts with four ratios of piperonyl butoxide and pyrethrins, but having the same calculated "total concentration" of active ingredients, were approximately equal in effectiveness.

From the results presented in this report it is concluded that marked synergism between piperonyl butoxide and pyrethrins can be demonstrated against the rice weevil, and further that this synergism is operative over a wide range of ratios of the two materials.

LITERATURE CITED

Beckley, J. A. 1948. Protection of grain against weevils. The East African Agric. Jour. **14**(2): 71–6.

Cotton, R. T. 1941. Insect pests of stored grain and grain products. Burgess Publishing Co., Minneapolis, Minn.

Cotton, R. T., J. C. Frankenfeld, and L. M. Redlinger. 1950. The treatment of railway boxcars with insecticidal sprays—a preliminary test. The Northwestern Miller, Milling Production, March.

Dove, W. E. 1947. Piperonyl butoxide, a new and safe insecticide for the household and field. Amer. Jour. Trop. Med. **27**-3).

Wachs, Herman. 1947. Synergistic insecticides. Science **105** (2733).

Control of Alfalfa Weevil in Hay Alfalfa with DDT Dust

F. V. Lieberman and S. J. Snow, *Bureau of Entomology and Plant Quarantine, Agr. Res. Adm., U.S.D.A.*, and C. J. Sorenson, *Utah Agricultural Experiment Station*

DDT is now in approved use throughout western United States for controlling insect pests of seed alfalfa. Recommendation for its use on hay alfalfa has been withheld by the United States Department of Agriculture and by the agricultural experiment stations of most States, pending careful appraisal of consequent hazards to the health of animals and man. As a part of an extensive cooperative study[1] of the toxicity of DDT-treated feed to farm animals and fowl, and ultimately to humans consuming the meat and other products of these animals, data were obtained on the effectiveness of several dosages of DDT in controlling the alfalfa weevil, *Hypera postica* (Gyll.), the principal insect pest of hay alfalfa in the Intermountain West. This paper presents the results of two experiments conducted near Logan, Utah, in 1947 and 1948, in which the treatments were applied to heavily infested alfalfa.

Experimental Procedure.—Sixteen 1-acre plots separated by buffer strips 100 to 150 feet wide were laid out in 4 blocks of 4 plots each in a 44-acre, dry-land, subirrigated, commercial alfalfa field. In 1947 treatments were randomized within each block. In 1948 the randomization was restricted to provide that the four replicates of each treatment would include one plot of each 1947 treatment. A single application of DDT dust was made to each of three plots in each block; the fourth was left untreated as a control. The dosages used in 1947 were 1, 2, and 4 pounds of technical DDT per acre. The second crop also was dusted with these dosages to provide additional DDT-treated hay for other phases of the study. Since no insects were present in economic abundance on the second crop, no report on insect control is included in this paper. In 1948 the dosages were changed to 0.5, 1, and 2 pounds per acre.

The DDT was procured as crop dusts containing 3, 5, 10, or 20 per cent of technical DDT mixed with pyrophyllite. The DDT content of the dusts was varied so that the amount of dust applied to obtain each desired dosage would approximate 20 pounds per acre. Applications were made with a power duster equipped with 12 V-type nozzles connected by separate lines of flexible 2-inch tubing to a common fan chamber. The duster was mounted on a small farm tractor and operated by connection with the power take-off. The tractor was driven at a speed of 5.5 miles per hour, blower-fan speed being maintained at approximately 4000 r.p.m.

The applications were made when the field as a whole began to show signs of economic damage. Weevil populations were estimated before and after treatment by taking 100 strokes with a 15-inch collecting net in each plot. Fifty strokes were distributed from corner to corner along the two diagonals of each plot. Insects collected were usually taken to the laboratory for counting.

Results.—Control of weevil larvae in the 1947 experiment (Table 1) was spectacular, and the protection afforded all 12 treated plots in comparison with untreated plots was remarkable. Not only was the severe feeding injury (Fig. 1) to the first growth minimized, but retardation of the second growth (Fig. 2), which was severe over much of the area in check

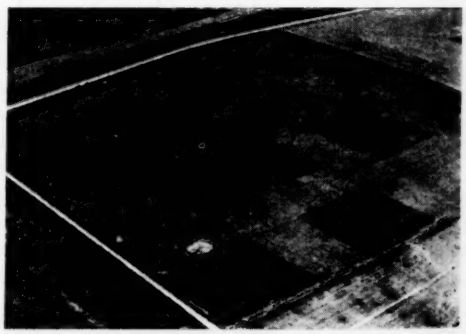

Fig. 1.—Aerial view just before harvest of the experimental acreage showing contrast between the 12 treated 1-acre plots, which appear dark, and the lighter colored damaged check plots and buffer strips.

[1] This study is supported in part by grants-in-aid from the U. S. Public Health Service to the Utah Agricultural Experiment Station. Other personnel of the Station participating in the project are Clyde Biddulph, project leader, D. A. Greenwood, L. L. Madsen, W. Binns, G. Q. Bateman, C. I. Draper, L. E. Harris, M. L. Miner, J. R. Harris, and M. J. Bryson.

Table 1.—Control of alfalfa weevil larvae with different dosages of DDT, 1947.

Date of Sampling	Days After Dusting	Larvae in Check Plots (100 Net Strokes)	Per Cent Control with Indicated Pounds of DDT per Acre		
			1	2	4
May 29	0	1357	—	—	—
June 4	6	5479	95	96	99
12	14	5551	92	93	97
18	20	4001	88	90	95

plots and buffer strips, was entirely prevented. These results were obtained even though the population of weevil larvae in this field was exceptionally large, and the weather during the interval from dusting to harvest was cloudy, cool, and rainy. The control obtained with calcium arsenate, the insecticide recommended for use against alfalfa weevil (Hamlin *et al.*, 1943), is generally 60 to 70 per cent, which is sufficient to prevent economic injury. Calcium arsenate could not have been relied on to give a satisfactory kill under the stormy conditions that prevailed during June 1947.

Such uniform excellence in control was not obtained in the second experiment, results of which are presented in table 2. Protection by the 2-pound treatment was comparable to that obtained in the initial test. The 1-pound treatment allowed noticeable feeding injury throughout the plots, but prevention of damage was rated as adequate. The 0.5-pound treatment failed to curtail feeding effectively, and economic damage occurred. Much of the difference in the degree of control obtained between the 1947 and 1948 experiments is attributable to the difference in developmental schedule of the weevil associated with climatological influences.

Table 2.—Control of alfalfa weevil larvae with different dosages of DDT, 1948.

Date of Sampling	Days After Dusting	Larvae in Check Plots (100 Net Strokes)	Per Cent Control with Indicated Pounds of DDT per Acre		
			0.5	1	2
June 6	0	1189	—	—	—
14	7	2213	58	71	83
17	10	2254	49	60	78
25	18	1906	46	60	69

FIG. 2.—The same field 2 weeks after harvest. Buffer and check plot areas are largely bare. Central portion of the acreage remained bare for 4 to 5 weeks.

Yield data are presented in table 3. In both experiments treated plots yielded significantly more hay than did untreated plots. However, yield differences between the DDT treatments were not significant. Protection was so nearly uniform in 1947 that the lowest dosage (1 pound per acre) was clearly adequate. In 1948 the lowest dosage (0.5 pound per acre) did not prevent economic damage, but the wide difference between replicates caused by unevenness in stand and growth of the alfalfa prevented demonstration of this inadequacy through yield data. In addition to increasing the yield, the DDT treatments improved the quality of the hay, particularly the carotene content (Harris *et al.* 1948).

Table 3.—Increased yields of hay associated with control of alfalfa weevil by application of DDT dusts.

Pounds DDT per Acre	Yield per Acre (Tons)		Per Cent Increase Due to Treatment	
	1947	1948[1]	1947	1948
None (check)	1.12	0.97	—	—
0.5	—	1.24	—	28
1	1.50	1.38	34	42
2	1.40	1.40	25	44
4	1.47	—	31	—
Average	—	—	30	38

[1] Not corrected to uniform moisture basis.

The DDT residue remaining in the cured hay from each treatment was determined, and the residue data for the three crops of hay alfalfa dusted are summarized in table 4. Residues reported are based on duplicate determinations run on

samples collected from 6 to 10 randomly chosen bales per plot. Analyses were made by the Chemistry Department of Utah State Agricultural College.

Table 4.—Residues of DDT in hay alfalfa treated with DDT dusts in 1947–48.

Treatment of Crop	1947		1948
	First Crop	Second Crop	First Crop
	Dates		
Dusted	May 29	July 14	June 7
Cut	June 19–22	Aug. 2–5	June 25–26
Bales hauled to barn	June 30–July 2	Aug. 16–19	July 8–10
Samples taken for residue determinations	June 30–July 2	Aug. 16–19	Jan. 1949
Determinations made	Apr. 1948	Apr. 1948	Feb. 1949
	DDT residues, p.p.m.		
Dosage of DDT (Pounds per acre)			
0.5	—	—	9
1	15	9	19
2	22	12	30
4	42	36	—

CONCLUSION.—Although DDT is shown by these experiments to be highly effective in controlling the alfalfa weevil in hay alfalfa, it is not at present recommended for such use. Alfalfa raised strictly for forage is fed largely to dairy animals and to meat animals being finished for slaughter, or is used in poultry feeds. Other phases of this investigation have shown that, when hay that has been treated with as little as 0.5 pound of DDT per acre is fed to sheep, dairy cows, and poultry, the DDT accumulates in the fatty tissues of the body, in the fat portion of milk, and in the yolk of eggs. Therefore, until the hazard to man arising from the feeding of animals on DDT-treated forage has been fully appraised, this insecticde should not be applied to hay alfalfa.

Preliminary experiments with a number of other new organic insecticides indicate that several, notably methoxychlor, lindane, and chlordane, are superior to DDT for control of alfalfa weevil. One or more of these insecticides may prove less objectionable than DDT for use on alfalfa grown for feed.

SUMMARY.—DDT was tested in 1947 and 1948 for its effectiveness in controlling larvae of the alfalfa weevil, *Hypera postica* (Gyll.), in hay alfalfa. DDT dusts in dosages of 0.5, 1, 2, and 4 pounds of the active ingredient per acre were applied with power equipment to replicated 1-acre plots in a heavily infested commercial field. Adequate to excellent control was obtained with as little as 1 pound of technical DDT per acre, but 0.5 pound did not prevent economic damage. Treated plots yielded from 25 to 44 per cent more hay than did untreated plots. The average DDT residue on the cured hay varied with the season and the dosage, ranging from 9 p.p.m. on 1948 first-crop hay treated with 0.5 pound of DDT per acre to 42 p.p.m. on 1947 first-crop hay treated with 4 pounds of DDT per acre. DDT is not recommended for use on hay alfalfa at this time, because the hazard to man arising from the feeding of DDT-treated forage has not been fully appraised.

LITERATURE CITED

Hamlin, J. C., W. C. McDuffie, F. V. Lieberman, and R. W. Bunn. 1943. Prevention and control of alfalfa weevil damage. U.S.D.A. Farmers' Bul. 1930.

Harris, J. R., C. Biddulph, D. E. Greenwood, M. J. Bryson, L. E. Harris, M. L. Minor, W. Binns, and L. L. Madsen. 1948. The concentration of DDT in the blood and tissues of sheep fed varying levels of DDT. Farm and Home Sci. (Utah Agr. Expt. Sta.) 9(3): 13–4.

OBERLY MEMORIAL AWARD

Ina L. Hawes and Rose Eisenberg, of the Bibliography Division of the U. S. Department of Agriculture Library, Washington, were announced recently in Atlantic City, N. J. as joint recipients of the Oberly Memorial Award, given by the American Library Association to the compiler of the best bibliography in the field of agriculture or the natural sciences.

The award, granted at two year intervals, consists of income from a capital fund contributed to the American Library Association as a memorial by the colleagues of Eunice Rockwood Oberly, late librarian of the Bureau of Plant Industry, U. S. Dept. of Agriculture. Twelve awards have been made by the A.L.A. since the establishment of the fund in 1925.

The bibliography selected for the 1949 award by the Oberly Memorial Fund Committee of the A.L.A. is on aviation and economic entomology, published in April 1947 by the U. S. Dept. of Agriculture. (US.D.A. Bibliog. B.8.)

Miss Hawes and Miss Eisenberg accepted the award in person at the American Library Association conference in Atlantic City.

Red Mite Control on Avocados and Mangos

D. O. WOLFENBARGER, *Sub-Tropical Experiment Station, Homestead, Fla.*

The avocado red mite. *Paratetranychus yothersi* (McG.), is one of the principal insect pests of the avocado and mango in Florida. This pest varies in its injuriousness from year to year, grove to grove, and to some extent among varieties. Severe mite populations may or may not coincide with severe infestations of the red-banded thrips, *Selenothrips rubrocinctus* (Giard), dictyospermum scale, *Chrysomphalus dictyospermi* (Morg.) or other insects. Although avocado red mite infestations on avocado and mangos have been satisfactorily controlled with sulfur and with oil emulsions, each of these insecticides has its weakness. Sulfur does not give scale control for example, and oil emulsion which gives both avocado red mite and scale control is likely to injure foliage so that growers do not like to use it. The choice of an insecticide for avocado red mite control should be made in consideration of the needs of individual groves and of the combination of insect pests present.

Tests have been conducted over the last 2-year period to determine the effectiveness of some older and newer materials for control of the avocado red mite and other avocado and mango pests. This presentation refers, however, to the red mite. The results are given in the chronological order in which an experiment was started, by date of application.

January 20, 1948.—In this experiment the Booth 7 variety of avocado was used in a test employing six trees per replicate and four replicates. Samples of five leaves per tree, from two trees per replicate, were examined for mite infestations at intervals after the spray treatments, made with a power sprayer. The results are summarized in table 1, giving the average number of living red mites per leaf and percentage control obtained.

Table 1.—Results from spray treatments applied to avocado trees, January 20, 1948.

Treatment Material	Amount of Material per 100 Gals. Water	Average Mites per Leaf		Percentage Control	
		1-day	7-days	1-day	7-days
Oil emulsion	2 per cent	0.4	0.1	95.0	99.5
Parathion, 25%	3 lbs.	0.1	1.1	98.8	92.8
Check		8.5	15.7	—	—

Both treatments gave excellent control. Although the percentage control obtained from parathion was decreasing on the 7-day count, no significance was attached to this until later tests also disclosed mite increases resulting from parathion treatments.

January 22, 1948.—Twelve treatments were included in this experiment. Single tree plots were used in each of six replicates of the Waldin Seedling 2-26 variety. The dust materials were applied by means of a rotary-type hand duster; the spray materials by a knapsack sprayer. Heavier dust applications were made than would be recommendable in order to emphasize any plant injury. Observations were made 4 days after the treatments. The results are summarized in table 2.

Sulfur and azobenzene gave excellent avocado red mite control. In this test the parathion dust and the proprietary selenium compound also gave good control. Other materials were relatively ineffective.

December 13, 1948.—In cooperation with the Sunland Groves, applications of parathion, oil emulsion, combinations of oil and parathion were put out in a grove of small 2-year old trees of mixed varieties in a field test. From 3 to 10 leaves were taken from each of 10 to 12 trees for examination on each date of observation for each treatment. The results of these observations are summarized in table 3.

Parathion gave a higher initial control but appeared to have given little residual control. The combination of parathion with oil gave the highest initial control and remained effective for at least 58 days. Oil emulsion gave excellent control.

December 22, 1948.—Trees of the Lula variety were treated with different amounts of parathion sprays, oil emulsions and wettable sulfur sprays. These were 16 year old trees in a three-row planting. Two-tree plots were treated in each of five replications of each material. The test here was made to determine the effectiveness of parathion sprays in dictyospermum scale control but data were also taken on avocado red mite control: these are herewith reported. Five

Table 2.—Results from spray and dust treatments applied to avocado trees Jan. 22, 1948.

Material	Amount per 100 Gal. Water, or Percentage in Dust	Average Mites per Leaf	Per Cent Control
Sulfur dust	—	0.7	97
Sulfur, wettable	10 lbs.	2.8	89
Dinitro-o-cyclohexyl phenol dust	1%	8.2	68
Dinitro-o-cyclohexyl phenol 40%	10 oz.	9.2	64
Azobenzene, plus oil[4] 1% plus wetting agent[1,5]	6 lbs. plus 1 gal. several c.c.	0.4	98
Azobenzene dust	5%	1.2	95
Di(p-chlorophenoxy) methane 40%	2¼ lbs.	11.6	54
Di(p-chlorophenoxy) methane dust	3%	6.9	73
Tetra ethyl pyrophosphate, 9%[2]	½ pt.	21.2	17
Parathion dust	1%	1.9	93
Potassium-ammonium-seleno-sulfide, 30%[3] plus oil[4] plus wetting agent	1 pt. plus 2 pts., plus 14 c.c.	1.6	94
Check		25.4	—
Least mean significant difference		11.0	

[1] *Triton B-1956.*
[2] *Vapotone.*
[3] *Selocide.*
[4] *Shell ACX 151.*
[5] Trouble was experienced with this treatment in getting a satisfactory dispersible mixture.

Table 3.—Results from spray treatments applied to avocado trees December 13, 1948.

Treatment	Insecticide per 100 Gals. Water	Average Number of Mites per Leaf, Days After Spraying				
		2	6	17	21	58
Oil emulsion	1.5%	2.4	2.8	0.1	0	0.3
Parathion, 15%	1 lb.	1.2	1.9	0.4	0	6.5
Parathion 15%, plus oil emulsion	1 lb. plus 1.5%	0	0.7	0.2	0	0.3
Check		26.6	5.9	2.3	1.6	9.2

leaves were examined for red mites from one tree in each of the five replicates, and at each of the different intervals after the treatments. The data are summarized in table 4.

Oil emulsion and wettable sulfur are seen to be the best control treatments up to 61 days after the applications. The averages for the 1-pound of parathion were practically the same as for the 4-pound treatment.

December 22, 1948.—Seventy-two trees of the Booth 7 variety were divided into four blocks, and each block was further divided into four plots. Four treatments were made in each block. The treatments

Table 4.—Results from spray treatments applied to avocado trees on December 22, 1948.

Spray Material	Amount or Concentration per 100 Gals. Water	Mites Present—Days After Treatment					
		6	14	28	40	61	Average All Samplings
Parathion, 15% w.p.	1 lb.	3.4	1.2	2.8	18.6	27.7	10.0
Parathion, 15% w.p.	2 lb.	7.2	1.8	5.3	16.3	36.0	12.2
Parathion, 15% w.p.	4 lb.	0.8	3.0	0.4	14.8	32.2	10.1
Oil emulsion	1.5 oil	0.8	0	2.6	0.6	4.9	1.7
Sulfur,	8 lbs.	0	0	0.2	1.1	13.4	2.9
Check		3.6	4.2	11.9	22.1	36.8	15.7
Difference for significance at 5% level		2.1	Insig.	Insig.	10.5	Insig.	8.1

Table 5.—Results from spray treatments applied to avocado trees on December 22, 1948.

Pounds 15% Wettable Parathion per 100 Gallons Water	Mites Present—Days After Treatment					
	6	12	26	36	54	Average All Samplings
Check, none	3.0	6.9	1.0	7.8	24.3	7.6
1	2.0	13.5	1.1	5.4	16.4	5.7
2	1.5	3.5	1.6	9.8	35.6	10.0
4	0.4	0.7	0.3	7.1	12.3	4.1

were made with a power sprayer using two four-nozzle guns to apply the sprays. Although this experiment was conducted to determine any dictyospermum scale control, data were taken on the avocado red mite infestations. Five leaves were detached from each of two trees in each replicate and examined for any avocado red mite at intervals after treatment. The results are summarized in table 5.

The data in tables 4, 5 and 6 show little consistent or plausible difference between treatments except on the 6 and 12 day counts. These counts suggest dosage responses which appear to have been entirely eliminated by the thirty-sixth day count. The check averages were never statistically greater than any spray treatment.

Wettable sulfur was applied to the trees on both sides of the rows of the trees used in the above described tests, summarized in tables 4, 5, and 6. There was a certain amount of drifting across the experimental trees. Sufficient drift apparently reduced the general red mite population level to low numbers until late in the season. It is interesting to note that the averages from the 2-pounds of parathion per 100 gallon dosage concentration, "all days" were higher on both avocado varieties, tables 4 and 5, than were those of the 4-pound dosage.

January 6, 1949.—Nine different dust treatments were made on young, 2-year old trees of the Waldin Seedling 2-26 variety. Some of the materials were dusted on foliage still wet with dew; some were dusted on dry foliage. Five replications of each treatment as single tree plots, with the treatments radomized, were used. Five leaves were taken from each tree on each date of the observations. A summary is presented in table 6.

All sulfur materials gave good results regardless of whether the foliage was dry or wet at the time of application. The average number of mites on the parathion dusted plants was always greater than it was on the check; the average of all days was exactly three-fold greater. There was no practical difference between the averages obtained from the different sulfur preparations.

MANGOS.—Although the mango is infested in some localities with the mite, *Septanychus tumidus* (Banks) which is not controlled with sulfur according to Tomasello (1949),[1] the avocado red mite which also infests the mango, is more generally

[1] Tomasello, Rudolph, 1949. Sprays for mangoes. Proc. Eighth Ann. meeting Fla. Mango Forum for 1948: 37–9.

Table 6.—Results from dust treatments made to avocado trees on January 7, 1949.

Foliage Condition	Material Concentration	Average Number of Mites per Leaf, Days After Treatments			
		17	33	66	Average All Samplings
Wet	Sulfur dust	0	0.1	1.0	0.5
Wet	Sulfur, wettable	1.0	0.1	2.0	1.2
Wet	Dusting sulfur, $\frac{2}{3}$, plus wettable sulfur, $\frac{1}{3}$	0.1	0.4	2.5	1.4
Wet	Parathion, 1%	3.8	24.4	2.8	12.9
Dry	Sulfur dust	0.1	0.1	3.0	1.3
Dry	Wettable sulfur	0	0.3	2.3	1.1
Dry	Dusting sulfur, $\frac{2}{3}$, plus wettable sulfur, $\frac{1}{3}$	0.1	0.7	1.8	1.0
Dry	Dusting sulfur, 95%, plus dust sticker[1]	0	0.7	2.3	1.3
Check		1.8	7.4	1.3	4.3

[1] Colloidal Products, *CP-5*.

Table 7.—Results of treatments made to mango trees on December 10, 1948.

Material	Concentration Used	Days After Treatment				
		3	10	20	28	Average All Samplings
Sulfur, wettable	8 lbs./100 gals.	2.5	37.6	2.9	13.4	14.1
Sulfur, wettable micronized	8 lbs./100 gals.	14.2	0	6.5	3.3	6.0
Dinitro capryl phenyl crotonate, 25%[1]	1.5 lbs/100 gals.	13.5	54.3	29.4	18.0	28.8
Sulfur, dusting		6.3	1.1	1.4	3.5	3.1
Sulfur, dusting, micronized		1.0	2.4	3.4	9.2	4.0
Sulfur, dusting, 95% plus dust sticker, 5%[2]		5.2	4.7	0.2	6.3	4.0
Parathion, 1%		9.7	93.7	34.7	93.6	57.9
Check		47.5	58.9	67.7	37.6	52.9

[1] *Arathane.*
[2] Colloidal Products, *CP-5.*

distributed, and is controlled with sulfur materials. Comparative effects of different sulfur preparations, of one per cent parathion dust, and of 1½ lbs. of 25 per cent wettable dinitro capryl phenyl crotonate powder per 100 gallons of water were obtained.

December 10, 1948.—The experiment was conducted in cooperation with Sunland Groves, in a planting of young 2.5 year old trees. The trees were of mixed varieties, spaced 30 feet apart each way. Little or no contamination of near by trees by the insecticides or of mite dispersal among the trees is considered to have occurred.

Both spray and dust treatments were applied with a small, power driven machine. There were eight treatments including the check, arranged in a latin-square plot design. The sprays were applied at about 2 quarts per tree at 225 pounds pressure. The dust materials were applied at about two ounces per tree. The applications were made to dry foliage, at a time when the leaves were showing symptoms of severe mite infestations.

Data on treatment results were taken by counting the mites on five leaves per tree on each tree of each treatment at various intervals. (See Table 7.)

Sulfur in all forms was very effective. The dust treatments were generally more effective than the spray treatments. Although the parathion gave great reductions on the 3-day count later observations showed that the treated plants had more mites than the check leaves.

SUMMARY.—Sulfur in whatever form used in a series of tests was very effective in control of the avocado red mite on avocado and mango trees. Oil emulsion sprays were also very effective in mite control. Other materials tried were parathion, dinitro-o-cyclohexyl phenol, azobenzene, di(p-chlorophenoxy) methane, tetraethyl pyrophosphate, a proprietary selenium compound, combination of sulfur and a dust sticker, micronized sulfur, and dinitro capryl crotonate, all of which proved relatively ineffective.

Eretmocerus serius as a Parasite of the Citrus Blackfly in Mexico

J. G. SHAW, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Eretmocerus serius Silv. is the only known parasite in Mexico of the citrus blackfly, *Aleurocanthus woglumi* Ashby. After an unsuccessful attempt to establish it in 1938, it was introduced from Panama in 1943 and colonized by Smith (1945) and Delgado (1943) in 15 citrus-growing areas on the West Coast from Colima to Los Mochis, Sinaloa. Since then this parasite has been colonized in most parts of Mexico where the blackfly is found. *E. serius* as observed has not except in one case, effected commerical control of the blackfly in Mexico, which

is contrary to the findings by Clausen & Berry (1932) in Cuba and the Orient, by Zetek[1] in Panama, and by Richardson (1948) in the Bahamas.

OBSERVATIONS IN MORELOS.—The first infestation of the citrus blackfly in the State of Morelos was discovered in a small citrus orchard at Huerta Santa Fe, near Cuernavaca (altitude 5000 feet). The insect was reported to have been brought in a few years earlier from Jalisco on small Valencia orange trees. *Eretmocerus serius* from Colima was colonized in this orchard by members of the Mexican department of Agriculture in the spring of 1945. The author followed its development there from October 1945 to April 1949. Parasitization counts were taken from 25 leaves containing clusters totaling 1000 to 2000 pupae from which blackflies and parasites had begun to emerge. The unemerged pupae were turned over, examined for parasite-entry scars, and then crushed to determine whether the body contained either a living parasite or a blackfly. If so, these pupae were included in the count. It was found that the old emerged clusters could not be used, because empty pupae from which blackflies had emerged usually sloughed off, while those from which parasites had emerged remained attached to the foliage.

Figure 1 illustrates the extreme fluctuation of citrus blackfly parasitization. It follows a uniform trend from year to year; *i.e.*, *Eretmocerus serius* builds up and causes a high rate of host mortality by the end of the rainy season (October), and then falls off rapidly as the dry season is prolonged into the spring months. The parasite is able to recuperate rapidly as the rainy season progresses, because of its short life cycle, which is only half as long as that of the blackfly (Clausen & Berry (1932)). In one example where parasitization was 85.1 per cent on November 8, 1947, it had dropped to 10.5 per cent by May 11, 1948, then increased to 18.7 per cent by May 31, after several rains, amounting to 1.69 inches had fallen between May 13 and 31. Many of the pupae dissected on May 11 contained dead adults of *E. serius*, as compared with only 14 dead parasites on May 31, suggesting that parasite mortality in the host is high when the weather is dry. During the dry period large numbers of parasites are

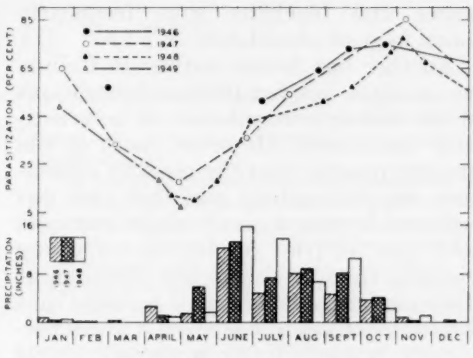

FIG. 1.—Parasitization of the citrus blackfly by *Eretmocerus serius* from February 1946 to April 1949 at Cuernavaca, Morelos. (Curve between points for February and July 1946 not completed because of lack of data.)

trapped on the foliage in the honeydew excreted by the blackfly and other citrus insects.

The long dry season in Morelos is typical of other parts of Mexico where both the citrus blackfly and *Eretmocerus serius* are found. This protracted drought interrupts normal parasite increase and development, while the blackfly infestation remains high and fruit production is largely inhibited unless insecticides are applied. Conditions necessary to enable the parasite to prosper throughout the year and to control the blackfly satisfactorily are found in Cuba and Panama, where rainfall is more evenly distributed during the year and the relative humidity is comparatively high.

OBSERVATIONS IN COLIMA.—From February 9 to 18, 1946, a survey by Shaw[2] of the blackfly situation in the extensive lime plantings around the city of Colima, Colima, revealed that *Eretmocerus serius* was not effectively controlling its host. The period of rainfall corresponds roughly with that at Cuernavaca, though the annual precipitation is only 30 inches, as compared with 40 to 50 inches for Cuernavaca. The growers reported that the adult parasite was most abundant in November and very scarce in the spring. from 41 samples of 10 to 20 infested leaves parasitization averaged 60.8 per cent, approximating that at Cuernavaca for the same time of year (Fig. 1). During this period of sampling adult parasites were

[1] Zetek, J. Official correspondence.
[2] Shaw, J. G. A report on the blackfly and its parasite, *Eretmocerus serius*, in the lime-growing section of Colima. [Unpublished.]

scarce and blackflies were frequently found in great abundance.

Another but briefer survey in Colima was made in October 1948, and conditions of the orchards were found to be practically unchanged. However, most of the growers insisted that the blackfly infestation was diminishing and that this was reflected in progressively slight increases each year of fruit production on young vigorous trees. A visit to new plantings at Tecoman on the Pacific coast revealed that *Eretmocerus serius*, colonized 3 years previously, was effecting commercial control of the blackfly. The coastal area there is several miles wide, very flat, and apparently more humid than 45 miles inland at Colima (1500 feet), though the rainy season is reported to be the same. Growers report that the coastal area is very humid throughout the year, except in March and April.

OBSERVATIONS IN OTHER STATES.—Samples taken from a few orange and grapefruit trees near Guadalajara, Jalisco (altitude 5100 feet), on February 7, 1946, were not found to be parasitized. It was reported that 492 adult parasites had been liberated in these trees in May or June 1945.

About the most heavily infested citrus orchards seen in Mexico by the writer were those observed in February 1948, at Los Mochis, Sinaloa, where parasites had been liberated in 1943. *Eretmocerus serius* was very scarce. The Los Mochis orchards grow at approximately sea level. They are well cared for, and, in contrast to conditions in Colima, ample water is usually available for irrigation in the dry season.

Parasites were liberated in several orchards at Valles, San Luis Potosi (altitude 250 feet), in 1947 and 1948 by the Mexican Department of Agriculture and by the growers. Several counts made over a period of a year from an orchard systematically colonized in 1948 showed parasitization ranging from only 4.0 to 31.2 per cent.

SUMMARY.—Samples of 25 leaves infested with the citrus blackfly, *Aleurocanthus woglumi* Ashby, were used at Cuernavaca, Morelos, to determine the effectiveness of the parasite, *Eretmocerus serius* Silv. Clusters of pupae from which blackflies and parasites had begun to emerge were used for making the counts. Studies made at Cuernavaca from 1945 to 1949 show that parasitization builds up to as high as 85 per cent by the end of the rainy season in October, dropping to as low as 8 or 10 per cent by May when the rainy season starts. Observations made in the States of Colima, Jalisco, Sinaloa, and San Luis Potosi, have with one exception, confirmed the findings in Morelos, that the long periods of drought appear to be the adverse factor preventing normal increase and development of the parasite while the blackfly infestations remain high and inhibit fruit production.

LITERATURE CITED

Clausen, Curtis P., and Paul A. Berry. 1932. The citrus blackfly in Asia, and the importation of its natural enemies into tropical America. U. S. Dept. Agr. Tech. Bul. **320:** 21–30.

Delgado de G., Alfonso. 1943. Control biológico de la mosca prieta de los cítricos en la república. Fitófilo **2**(5): 3–17.

Richardson, H. H. 1948. Present status of the citrus blackfly and its parasite *Eretmocerus serius* at Nassau, Bahamas. JOUR. ECON. ENT. **41:** 980.

Smith, Herbert D. 1945. La "Mosca Prieta" de los citricos en la costa occidental de Mexico y la importación y colonización de *Eretmocerus serius* Silv. para su control. Fitófilo **4**(2): 67–103.

DR. CRAIGHEAD RETIRES

Dr. Frank C. Craighead, well-known authority on forest insects, retired May 1, 1950 from the Bureau of Entomology and Plant Quarantine after having had charge of the investigations on insect pests of forests and forest products for nearly 27 years. Dr. Craighead entered the federal service in 1910 as a temporary Forest Guard in the Forest Service, and except for a three-year period as Forest Entomologist for the Canadian Government, he was in the service of the U.S.D.A., until his retirement. Dr. Craighead will return to a farm near Craighead, Pa.

SCIENTIFIC NOTES

Environmental Resistance as a Factor in Codling Moth Control on Walnuts

A. E. Michelbacher, W. W. Middlekauff and Donald Davis, *University of California, Berkeley*

It is usually necessary to apply sprays each year to control the codling moth on susceptible varieties of walnuts. Because of this the impression is often obtained that natural environmental factors are not important in regulating the population. Yet it is known that the population shows considerable fluctuation over a period of years, and evidence obtained at Linden, California, indicates that the environment exerts an important regulating influence upon the pest. However, under an effective spray control program, it is usually difficult to detect the effect of these natural controlling factors, because of the suppressed population.

In 1942 when the codling moth investigation was undertaken at Linden, the infestation was of serious proportions, and the number of infested nuts in the harvested crop from check trees exceeded 25 per cent. With subsequent years, the control program was greatly improved and the seriousness of the infestations as measured by the amount of infested nuts in the check trees declined so that by 1945 it was 6.8 per cent, and in 1946 it was 7.0 per cent. From these data it would appear that the reduction in the seriousness of the problem was due to the effectiveness of the codling moth spray control program. However, this was probably not the case, for although the same program was continued, the infestation in the harvested crop in the check trees reached 44 per cent in 1948 and was 22 per cent in 1949. These increases in infestations could not be attributed to the insect becoming resistant to standard lead arsenate for, in spite of the heavy infestation, excellent control was obtained where sprays were properly timed and carefully applied. Further, there was a general increase in the infestation even in orchards or areas where no sprays were applied. There can be but little question that climatic and biotic factors were important in influencing the size of the codling moth population. It appears that when these factors afford a high environmental resistance the codling moth population is reduced and spray control programs benefit. However, when these factors favor the codling moth, spray programs are put to a severe test and satisfactory control can be obtained only where they are properly timed and thoroughly applied.

The action of natural controlling factors becomes more apparent with an increase in population. This is particularly true in regards to predators and parasites, which often occur in large numbers when their host becomes very abundant. To some extent this happened with the codling moth during the 1949 season. There was a very large second brood of codling moths, and in the experimental orchard there was a heavy deposition of eggs. The average number of eggs per nut was something more than 1.75, which was considerably higher than usually encountered. The eggs were heavily parasitized by *Trichogramma embryophagum* Hartig.[1] Parasitized eggs usually contained three parasites. A number of surveys were made to determine the degree of parasitism and the information obtained is given in table 1. It should be noted that approximately 50 per cent of the eggs laid were parasitized. Although the amount of parasitism was insufficient to successfully control the codling moth, the data show that the large codling moth population created conditions favorable for a rapid rise in a parasite population. The conflict between the codling moth and its natural controlling factors is always present, but the value derived is seldom clearly seen. A more thorough knowledge concerning the relations that exist between the two is certainly deserving of intensive investigations.

It appears that environmental resistance plays an important role in the success of a codling moth spray control program on walnuts. Apparently satisfactory control is easily obtained when it is at a high level, but when it is low, timely and thorough applications are necessary for successful control.

Because of the powerful natural environmental factors that tend to regulate the codling moth population every effort should be made to avoid practices that might shift them to favor the codling moth. Control measures should be used with discrimination, applied only when needed, and the insecticide used at a rate no higher than necessary to insure satisfactory control.

Table 1.—Parasitism of second brood codling moth eggs by *Trichogramma embryophagum* Hartig in the experimental orchard at Linden, California, 1949.

Date	Total Number of Eggs	Condition of Eggs											
		With Dead Larvae		Hatched		Not Hatched		Parasitized					
								Not Emerged		Emerged		Total	
		Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
July 26	210	—	—	57	27.1	39	18.6	51	24.3	63	30.0	114	54.3
Aug. 1	208	9	4.3	55	26.4	21	10.1	49	23.6	74	35.6	123	59.1
Aug. 3	214	9	4.2	75	35.0	5	2.3	51	23.8	74	34.6	125	58.4
Aug. 11*	144	5	3.5	109	75.7	1	0.7	19	13.2	10	6.9	29	20.1
Aug. 25*	203	4	2.0	117	57.6	0	0.0	16	7.9	66	32.5	82	40.4

* Survey conducted in a portion of the orchard ½ mile from the previous survey area.

[1] Identified by S. E. Flanders, Division of Biological Control, Citrus Experiment Station, Riverside, California.

Insecticide Tests with Cabbage Caterpillars[1]

L. E. DILLS and M. L. ODLAND[2]

Several workers (Smith & Harrison 1944), (Apple 1945), (Bruce & Tauber 1945) have reported field experiments using DDT for cabbage caterpillars. Huckett (1946) compared DDT and dichlorodiphenyl dichloroethane for the control of caterpillars attacking cauliflower. More recently Dills & Odland (1948) and Reid & Cuthbert (1949) compared DDT with some of the other newer compounds. Since several of these compounds have been found to be much better than the older inorganic materials which had previously been used for these insects it seemed advisable to continue the experiments. For that reason additional field tests were conducted in 1948 and 1949.

METHODS.—In both years the plot arrangement was a randomized block with six replications. In 1948 a plot consisted of two rows each 27 feet long while in 1949 a plot consisted of three rows each 27 feet long. An untreated buffer row was left between plots. The variety used was Penn State Ballhead.

The materials were all applied as dusts and the carrier used for dilution consisted of 75 per cent pyrophyllite and 25 per cent hydrous aluminum magnesium silicate. A crank-type duster was used in making the applications and all dusts were applied as uniformly as possible. Three applications were made with intervals of 2 or 3 weeks.

Since the caterpillars found on cabbage are not equally susceptible to toxic compounds (Huckett 1946), (Reid & Cuthbert 1949) it is necessary in evaluating control measures to determine which species is causing the injury. In both years in September when the feeding rating was taken the relative abundance of each species was determined. In 1949 an earlier count was also made.

An average of approximately 28 plants per plot in 1948 and 30 plants per plot in 1949 were examined and rated for feeding injury on a scale of 1 to 10 (see footnote table 1). Yield records were only taken in 1949. In order to facilitate the interpretation of the results the yields are expressed in tons per acre.

RESULTS.—The larvae of the imported cabbage worm *Pieris rapae* (L.), cabbage looper *Trichoplusia ni* (Hbn.) and the diamond back moth *Plutella maculipennis* (Curt.) were present in the plots at all times but their relative abundance varied considerably because of parasitism and disease. In the untreated plots on September 16, 1948 the relative infestation was 84.3 per cent imported cabbage worm, 12.4 per cent cabbage looper and 3.3 per cent diamondback moth. The following year the relative infestation on August 11 in the untreated plots was 14.8 per cent imported cabbage worm, 62.6 per cent cabbage looper and 22.6 per cent diamondback moth. Later in the summer the looper was attacked by a disease which reduced its numbers so that the imported cabbage worm predominated. On September 14 the relative abundance in the untreated plots was 54.7 per cent imported cabbage worm, 44.7 per cent cabbage looper and 0.6 per cent diamondback moth.

Sufficient data are not available to determine the relative infestation of the plots treated with different materials.

Tables 1 and 2 show that all concentrations of DDT gave very good results both years in preventing damage from cabbage caterpillars. It was exceeded only by dieldrin in 1949. Although the difference is not significant it should be noted that not only was there less feeding where dieldrin was used but the yield was higher and this occurred at both the one and the two per cent concentration.

In 1948 dichlorodiphenyl dichloroethane gave results almost identical to those from DDT and, although there was more variation, the results for the following year were also similar. When the dusts were used at 2 per cent in 1949 the cabbage treated with dieldrin, DDT and dichlorodiphenyl dichloroethane had a significantly better feeding rating than that treated with aldrin but the difference in yield was not significant. The previous year the plots treated with aldrin at 1.5 per cent showed more feed-

Table 1.—Relative effectiveness of various dusts for cabbage caterpillars in 1948.

INSECTICIDE	PER CENT CONC.	AVERAGE FEEDING RATING
DDT	1	2.20
	2	2.13
	3	1.99
Dichlorodiphenyl dichloroethane	1	2.14
	2	2.13
	3	2.04
Toxaphene	2	2.38
	3	2.04
Aldrin	1.5	2.48
Chlordane	3	3.79
7-chloro-5-methyl-1,4,2-benzothiazine-3(4)-one	5	5.16
Untreated	—	6.01
Difference required for significance at the 5% level		0.53

Rating scale: 1=no injury; 2=very slight; 3=slight; 4=slightly +; 5=moderate −; 6=moderate; 7=moderate +; 8=severe −; 9=severe; 10=very severe.

[1] Authorized for publication on February 27, 1950 as Paper No. 1583 in the Journal Series of the Pennsylvania Agricultural Experiment Station.

[2] Associate Professor of Economic Entomology and Professor of Olericulture, respectively.

Table 2.—Relative effectiveness of various dusts for cabbage caterpillars in 1949.

INSECTICIDE	PER CENT CONC.	AVERAGE FEEDING RATING	TONS PER ACRE
Dieldrin	1	3.06	23.2
	2	2.63	23.0
DDT	1	3.11	19.8
	2	2.94	21.1
Dichlorodiphenyl dichloroethane	1	3.71	20.8
	2	2.86	20.6
Aldrin	2	3.73	20.8
	3	3.41	21.6
Toxaphene	1	5.02	19.0
	2	3.84	21.6
	3	3.25	22.8
Ditolyl trichloroethane	2	6.28	17.4
	3	6.10	16.0
Untreated	—	7.71	14.9
Difference required for significance at the 5% level		0.71	3.7

ing but not significantly more than DDT or TDE at 1, 2 or 3 per cent and toxaphene at 2 and 3 per cent. For that year aldrin at 1.5 per cent was found to be significantly better than chlordane at 3 per cent. Although the feeding rating for toxaphene was not significantly inferior to DDT or TDE in 1948, the following year when compared at 2 per cent there were significant differences. Earlier work (Dills & Odland 1948) had shown that chlordane was inferior to DDT and dichlorodiphenyl dichloroethane. In 1948 it was found to be inferior to all except 7-chloro-5-methyl-1, 4, 2-benzothiazine-3(4)-one. The results for the following year showed that ditolyl trichloroethane had little value in preventing injury from cabbage caterpillars.

DISCUSSION.—Previous work had shown that some of the new chlorinated compounds were much superior to the arsenates which were formerly recommended for caterpillars feeding on cabbage. The best results have been obtained with dieldrin, DDT and TDE. Over a period of 4 years DDT has given excellent results. TDE used in comparison with it for 3 years has been found to be approximately its equal. Dieldrin has been used only 1 year but indications are that further trials may show it to be superior to DDT. Aldrin and toxaphene were found to have considerable merit but were inferior to dieldrin, DDT and dichlorodiphenyl dichloroethane. Chlordane was less effective and the results for 1 year indicated that ditolyl trichloroethane and 7-chloro-5-methyl-1, 4, 2-benzothiazine-3(4)-one were quite ineffective.

SUMMARY.—Additional plot tests have been made for 2 years to determine the comparative effectiveness to cabbage caterpillars of eight selected materials. All compounds were used as dusts and the more effective ones were used both years. All except two were tested at several different concentrations. Best results were obtained with dieldrin, DDT and dichlorodiphenyl dichloroethane.

LITERATURE CITED

Apple, J. W. 1945. DDT to control cabbage caterpillars. JOUR. ECON. ENT. **38**(3): 410.

Bruce, W. N. and O. E. Tauber. 1945. Trials with DDT on potatoes, cabbage, and squash. JOUR. ECON. ENT. **38**(4): 439–41.

Dills, L. E., and M. L. Odland. 1948. Cabbage caterpillar insecticide tests. JOUR. ECON. ENT. **41**(6): 948–50.

Huckett, H. C. 1946. DDT and other new insecticides for control of cauliflower worms on Long Island. JOUR. ECON. ENT. **39**(2): 184–8.

Reid, W. J., Jr., and F. P. Cuthbert, Jr. 1949. Field-plot comparisons of DDT and other new materials for control of caterpillars on cabbage. U.S.B.E.P.Q. E-**787.**

Smith, C. E., and P. K. Harrison. 1944. Field tests with DDT and other insecticides against cabbage caterpillars. JOUR. ECON. ENT. **37**(1): 152–3.

The Sugar-Cane Rhinoceros Beetle

GEORGE N. WOLCOTT, *Agricultural Experiment Station, University of Puerto Rico*

Grubs of the sugar-cane rhinoceros beetle, *Strataegus barbigerus* Chapin, were often a major pest (Smyth 1920) of young plant cane, before the introduction of the giant Surinam toad, *Bufo marinus* (L.), into Puerto Rico. Despite the comparatively large size and bulk of the beetle, and the horns present on the prothorax of the males, and the numerous sharp spines of the legs, it was not large enough or spiny enough to prevent consumption by the introduced toad (Dexter 1932). Indeed at the time of greatest abundance of the toad, the rhinoceros beetle had apparently disappeared from the fauna of the Island, and not only the beetles, but also their specific Scoliid parasite, *Campsomeris atrata* (F.), not a single specimen of which has been collected in Puerto Rico in recent years. By contrast, in the near-by island of Mona, where *Bufo marinus* does not occur, Dr. Luis F. Martorell in the spring of 1940 collected numerous females on flowers of *Moringa oleifera*, *Pisonia albida* and *Colubrina ferruginosa* and saw many more, while additional wasps, as well as specimens of the host beetle, have been noted on Mona at other times when entomologists have been there to make the observations (Ramos 1947). As the introduced toad decreased in abundance in Puerto Rico, occasional specimens of the rhinoceros beetle have been collected, and of the white grubs sent in last year from Isabela and Aguirre for insecticide experiments, a small percentage were of the rhinoceros beetle. Out of 25 grubs recently sent from Isabela this year, seven were of the rhinoceros beetle; a striking indication of how greatly it has increased in abundance after the many years during which the introduced toad appeared to have caused its local extermination.

LITERATURE CITED

Dexter, Raquel R. 1932. The food habits of the introduced toad, *Bufo marinus*, in the sugar-cane sections of Porto Rico. Fourth Congress, International Soc. Sugar-Cane Technologists, Bul. 74: 6, ref. 6. San Juan, March 1932.

Ramos, J. A. 1947. The insects of Mona Island (West Indies). Jour. Agr. University of P. R., **30**(1): 1–74.

Smyth, E. G. 1920. The white grubs injuring sugar-cane in Porto Rico, II. The rhinoceros beetles. Jour. Dept. Agr. P. R., **1**(2): 1–31.

On the Host-Ectoparasite Relation

LEO KARTMAN, *Johns Hopkins School of Hygiene and Public Health, Baltimore, Md.*

A recent paper by the writer (1949) has presented experimental evidence that chickens deprived of the distal half of their upper mandible had, on the average, a higher degree of pediculosis with the chicken body louse than their non-debeaked coop mates feeding on the same ration. This experiment was designed to test the hypothesis that, although other factors may be of importance, host activity, as expressed by mechanical delousing reactions, must be taken into account in explanations regarding the nature of the host-ectoparasite relation. Basic physiological factors which inhibit preening or grooming reflexes may produce a condition in which the ectoparasite population increases unchecked. It was suggested that although this mechanical factor may depend upon the nutritional state in some cases, it was independently a limiting condition, along with nutrition, in determining the nature of the ectoparasite economy on a given host.

In this connection, the writer's attention has been

directed to a note by Worth (1940) on the dissemination of Mallophaga presenting evidence from nature which is an amazing correlation with the experimental data mentioned above. Worth trapped a junco, *Junco hyemalis hyemalis*, heavily infested with the mallophagan, *Degeeriella* sp. This individual was unique in that, of all the birds trapped, it had an intense infestation with lice as compared with the usual low incidence of ectoparasites.

The explanation of this condition was suggested by the fact that the distal portion of the upper mandible was missing. The indications were that it was an old deformity, nevertheless the bird appeared to be in general good health. Although the bird could obtain food with this deformed beak it could not carry on normal preening activity. This constitutes a condition analogous to that produced in the experimental chickens by the writer's recent experiment.

Worth further presented the theory that a bird of this sort might become the center from which other birds derive their infestations since an immense number of lice "can congregate on an individual bird as soon as its ability to preen itself is interfered with." He even suggested that ectoparasites may "regularly depend on birds with deformed bills for their dissemination within the population." Although this hypothesis appears extreme it nevertheless emphasizes the importance of host activity as such, a circumstance which should be recognized by workers attempting to study the limiting factors in the host-ectoparasite complex.

It may be useful to think of an ectoparasite species as consisting of a series of populations of freely interbreeding individuals confined to individual hosts in a given geographic region. Although these populations may be in frequent contact, thus allowing more or less inter-host migration, the important factors for each population are the physiological and morphological peculiarities of the host together with its complex of habit patterns. It may be that these habits constitute ecological factors of great importance to the survival of the ectoparasite species. The survival value of the ability to escape delousing actions of the host may be as significant in the evolution of efficient ectoparasitism as is the survival value to certain endoparasites of the capacity to withstand the action of the host's digestive enzymes.

LITERATURE CITED

Kartman, L. 1949. Preliminary observations on the relation of nutrition to pediculosis of rats and chickens. Jour. Parasit. **35**(3): 367–74.

Worth, C. Brooke. 1940. A note on the dissemination of Mallophaga. Bird-Banding **11** (1): 24.

Oncopeltus fasciatus Reared for Laboratory Testing on Watermelon Seeds

A. O. LEA and R. E. NISWANDER, Entomological Laboratories, Ohio State University

The food of the milkweed bug *Oncopeltus fasciatus* (Dallas) is the seeds of the milkweed plant. This insect has been reared in the Ohio State Entomology laboratory for a number of years on milkweed seeds collected each year in the field. Efforts to purchase the seeds from a commercial company have not been successful to date, with the result that the supply of seeds must be used sparingly in anticipating a poor year for field collection of the seeds. It has been observed that if sufficient food is not available there is a decrease in egg production, lack of vigor in the individuals and smaller size of the adults. In a testing program it is essential to have a large stock of test insects at all times and to have individuals of as nearly uniform vigor and size as possible. Furthermore, considerable time is consumed in collecting and cleaning of the seeds.

It was with these points in mind that tests were made to find whether there were other food substitutes easily available and in large quantities. Some of the substitutes tested included raisins, whole and crushed, kidney beans, rolled oats, squash, cantaloupe and watermelon seeds. The bugs did not feed on the watermelon seeds unless the seed coat was removed or cracked. First instar nymphs matured and produced fertile adults when fed on the exposed embryo. Seeds were run through a hammer mill with no screen so that they were just cracked open. The bugs apparently cannot feed on finely ground seeds but must probe the seed with their proboscides. The ground embryo and seed coats need no separation before being used.

Present tests indicate no difference in the rate of development, size or vigor of individuals reared on watermelon seeds compared with those reared on milkweed seeds.

Watermelon seeds can be purchased for about 25 cents a pound. This makes a relatively inexpensive and easily available food substitute for laboratory rearing.

Oil Emulsion to Control Rhodes Grass Scale

GEORGE P. WENE and PAUL T. RIHERD, *Texas Agricultural Experiment Station, Weslaco*

The Rhodes grass scale, *Antonina graminis* (Maskell), is very destructive on pastures, lawns and golf greens in the Lower Rio Grande Valley. During the latter part of March, 1947, the nymphal state was observed crawling on grass during the heat of the day on all of some 50 lawns inspected in this area. An oil emulsion spray containing 1.6 per cent oil was applied on square yard plots at an estimated rate of 150 gallons per acre. The control plots were at least 10 feet away from the sprayed plots so as to minimize the effect of the oil emulsion drift. There were four replications in the first experiment and three in in the second one. Effectiveness of the treatment was determined by counting the number of nymphs in five 9-square inch areas, selected at random in each plot.

Data taken one day after treatment application showed an average 14.2 dead nymphs and 0.4 live lymphs per 9 square inch sample area, while the untreated area averaged 9.8 live nymphs. Data taken four days later showed 2.5 live nymphs per sample area in the treated plots, while the nymphal population had increased to 14.2 nymphs in the untreated plots. Similar results were obtained in the second experiment. The data showed that an oil emulsion controlled the nymphs of the Rhodes grass scale but the effectiveness of the treatment application was gone 3 days after treatment applications. The number of nymphs found 3 and 4 days after treatment application indicate that the 1.6 per cent oil emulsion treatment had little or no effect on the adult scale.

The Blueberry Flea Beetle

F. R. SHAW, J. S. BAILEY and E. H. WHEELER,
Amherst, Massachusetts

In 1947 the producers of low bush blueberries in Granville and Blandford, Massachusetts were faced with an insect problem new to the area. Upon investigation, the insect was found to be the blueberry flea beetle *Altica sylvia* Malloch. It has occurred as a pest for years in the blueberry barrens of Maine and probably has been present in Massachusetts for some time.

In Maine, the insect is reported to winter over in the egg stage. Hatching occurs in early spring and the larvae feed on buds and leaves of the low bush varieties of blueberries. The feeding period requires 2 to 3 weeks and by the last of June, practically all larvae have pupated. The pupal period lasts for 10 to 18 days; the adults appearing about July 1. These feed on the foliage and about the last of July are said to deposit their eggs singly on or near the ground.

Control measures in Maine have consisted of burning over infested areas in the spring for the purpose of destroying the eggs. Lathrop (1948)[1] stated that there is a growing tendency to apply DDT on valuable sections to control newly hatched larvae. He did not recommend DDT applications later than the blossoming period for the following reasons—

"1. DDT applied to open blossoms may kill bees.
2. DDT applied to the berries may result in undesirable residues at picking time.
3. Two applications of DDT in July 1947 reduced the size of the berries and decreased the yield."

Lathrop is of the opinion that a 50-10-40 calcium arsenate-copper sulfate-hydrated lime dust, applied at 6 lbs. per acre to control blueberry fruit fly, kills many adult flea beetles.

In the spring of 1948, the infestation in Massachusetts had become sufficiently widespread and destructive to cause concern among the growers. On June 10, J. S. Bailey and F. R. Shaw visited the area and about 18 acres of bushes were found defoliated.

At the time of this examination, larvae were abundant. Both buds and leaves were completely destroyed in heavily infested areas. Where the damage was not so severe, the presence of the insects could be detected by a characteristic scalloping of the leaf margins.

The preliminary examination also revealed the presence of one adult beetle. The finding of this adult at this season introduced the possibility that the flea beetle may pass the winter in this stage in Massachusetts. Of course it is possible that this individual had completed its development from an egg hatched early in the same year.

On June 28, the area was visited again and the adults were found to be very abundant. Pupae and one immature adult were found in chambers in the soil within 0.5 inch of the surface.

Adults were taken to the laboratory of the University at Amherst, Massachusetts and caged on blueberry plants. Frequent observations failed to reveal either copulating beetles or the act of oviposition. On July 23, two whitish eggs were found on the stem of one plant. These did not develop and later dropped from the stem so that their identity is not certain.

On July 9, preliminary control treatments were conducted on small plots of heavily infested bushes. The insecticides tested included a 5 per cent DDT dust, a 1 per cent parathion dust and a commercial tetraethyl pyrophosphate at the rate of 5 cc. of 35 per cent concentrate to 3 gallons of water. For application, a small plunger duster was used for the dusts and a 3 gallon compressed air sprayer for the liquid.

The effects of tetraethyl pyrophosphate and parathion were evident almost immediately. The adult beetles contacted by these materials dropped from the foliage within 10 to 15 minutes after the treatment. Those dusted with parathion showed more agitation before dropping from the plants. In the case of DDT treated beetles the immediate effects were not as pronounced.

Specimens of the insects were collected at random from each of the treated plots. These were taken to Amherst, placed in cages and provided with water and untreated blueberry foliage. The data obtained are recorded in table 1.

Table 1.—Effects of insecticides on blueberry flea beetle.

Materials Used	5 Per Cent DDT Dust			1 Per Cent Parathion Dust			Tetraethyl Pyrophosphate 1–2500		
Length of time	[1]D	M	A	D	M	A	D	M	A
6 hours	2	9	7	12		2	7	10	4
48 hours	2	3	13	13		1	15	2	4
72 hours	18		0	13		1	18	0	3

[1] Letters D—M—A indicate dead, moribund and alive. The use of the term moribund was made necessary since some of the insects knocked down were active on later examinations.

It is evident that all of these materials were highly toxic to the blueberry flea beetle adults. Probably from the standpoint of cost and residual toxicity, DDT would be preferable to the other materials tested.

In late October, observations were continued to determine, if possible, what stage of the insect was present.

Duff from the bases of the plants was collected and examined for eggs. The plants were also scrutinized carefully. Many yellowish elongate eggs were found in the duff but on examination all were seen to be hatched. One adult flea beetle was found. We could therefore neither confirm nor deny the report that the insect winters in the egg stage.

A final point of interest was the finding of a mealybug, *Phenacoccus flaveola* on the roots of blueberry plants at this time.

LITERATURE CITED

Phipps, C. R. 1930. Blueberry and Huckleberry Insects. Maine Expt. Sta. Bul. **356**: 107–232.

Wood, W. C. 1918. Biology of Maine Species of *Haltica*. Maine Expt. Sta. Bul. **273**: 149–204.

[1] Personal communication.

Screw-Worm Survey in Western United States, 1949[2]

E. W. LAAKE, *U.S.D.A., Agri. Res. Adm., Bureau of Entomology and Plant Quarantine*

The annual survey of screw-worms, *Callitroga americana* (C. & P.), conducted by the Bureau of Entomology and Plant Quarantine in cooperation

[2] Presented at the meeting of the Texas Entomological Society at Houston, Tex., January 19–20, 1950.

with State extension specialists was continued in most of the States usually affected in western United States during 1949. The early scouting was confined to Texas and Arizona to determine the winter-survival area of this insect. This fly does not overwinter in any other State west of the Mississippi, except possibly in southern California.

The early survey failed to reveal the survival of the screw-worm in Arizona in domestic animals, but subsequent scouting indicated that the insect survived the winter in southern Arizona, apparently in infestations in wild animals. In southern Texas the winter-survival area was found to extend at least as far north as Kendall County, just north of San Antonio. Screw-worm infestations in domestic animals were also reported throughout the winter as far north as Kinney County, on the Rio Grande, along the western border of the State, and at least to Refugio and Bee Counties along the eastern coast. The winter-survival area in Texas was somewhat larger and extended farther north than usual, notwithstanding the coldest winter temperatures recorded in this area since the survey was inaugurated in 1943. The 1948–49 winter survival of the fly farther north than usual was indicated to be due to the well-timed periodical warm spells, which prevailed at intervals during the winter, when they were critical for adult activity and the continuation of the life cycle of the screw-worm.

The population of screw-worms that survived the 1948–49 winter in southern Texas was definitely greater and more widely distributed than during any other winter since the survey was started. In addition, Texas subsequently had an excellent all-season environment for screw-worm development, owing to frequent and abundant precipitation, especially throughout the usually drier areas of the State, which otherwise checks screw-worm breeding considerably during the summer. This combination of factors so favorable for screw worm development resulted in one of the heaviest and most destructive screw worm seasons the State has experienced in many years. Similar favorable weather conditions in Arizona and New Mexico also resulted in a heavy screw-worm incidence later in the season in some areas of both States.

Early season scouting in Louisiana, Arkansas, and Oklahoma revealed only light to moderate infestations in selected livestock counties well scattered throughout these States. Later in the season, however, Oklahoma reported a heavy screw-worm incidence in the western part of the State, principally along the Texas Panhandle.

Kansas and Missouri were surveyed during midsummer. Scattered light to moderate infestations were found in 24 of 37 counties scouted in Kansas. Nearly all the infested counties were located in the eastern half of the State, in the Flint Hills grazing area, into which several hundred thousand southern feeder cattle are imported early each season for fattening on grass during the spring and summer. The screw-word infestations in some of the Kansas counties were still confined to definitely isolated area within the affected counties. This is a common occurrence in this and other North Central States each year and is the result of early season importation of screw-worm-infested animals. In Missouri 18 of 23 key counties well scattered over the State were lightly to moderately infested. Here, too, the isolated infestations in various parts of the State resulted from importing screw-worm-infested animals. Reports received from veterinarians subsequent to our survey indicated that screw-worms invaded most of the counties in the western half of Kansas late in the season and caused considerable damage to livestock and also entailed expense for the care of infested animals.

In Nebraska only seven of 21 counties located along the Kansas and Iowa borders were found to be infested rather late in the season—September—when the survey was made. Six of the infested counties were grouped around Omaha, where the national stockyards and packing houses are located and which receive many southern cattle all season long. The other infested county was located in the extreme southeastern corner of the State. The infestations were light except in Douglas County, in which Omaha is located, and in the adjoining Sarpy County, in both of which a heavy infestation was reported. The Nebraska infestations undoubtedly resulted from the importation of screw-worm-infested animals from the South.

The survey in Iowa, also made late in the season, was confined to scattered counties in the southern part of the State and northeastward to Fayette County. A total of 17 counties were scouted, five of which were infested. Pottawattamie County, across the State border from Douglas County and Omaha, Nebr., and Black Hawk County, in east-central Iowa, were reported as heavily infested. Both these infestations, as well as the lighter infestations found in three southwestern counties, were the result of importations of infested animals earlier in the season.

Scouting in Illinois was limited to four counties in the southern part of the State, none of which were infested. A shortage of scouts, and also severe outbreaks of screw-worms in South Dakota and Indiana, made it necessary to discontinue the survey in Illinois shortly after it was started.

South Dakota experienced one of the worst screw-worm outbreaks encountered since the survey was inaugurated in 1943. The outbreak resulted from the importation of possibly not more than two infested animals from Texas which were shipped directly to the vicinity of Van Metre, in Jones County, about the middle of May. The infestation became established and subsequently built up a fly population that spread over 15 counties and caused at least 13000 cases of screw-worms by the end of August. The most seriously affected county was Jones, in which 15 per cent of the domestic animal population became infested in short order. It was estimated that more than 6340 animals became infested in Jones County before the fly was brought under control. Other counties seriously affected were Dewey, Haakon, Hughes, Jackson, Lyman, Mellette, Stanley, Sully, and Ziebach. Other infested counties less seriously affected were Armstrong, Buffalo, Meade, Pennington, Potter, Tripp, and Washabaugh.

By the end of August the infestation in South Dakota had spread over an area that measured approximately 148 miles from east to west and 125 miles from north to south. Notwithstanding heroic efforts by the livestock owners, who were not familiar with the control of the screw-worm when it first appeared but who soon learned to use Smear 62, the infestation in South Dakota was not eradicated until winter weather stopped adult activity.

Indiana became infested in May through the importation of a shipment of infested sheep from Oklahoma. The sheep were brought into Lawrence County, where the infestation became established and subsequently spread over 21 southern counties,

11 of which developed county-wide infestations ranging from 0.1 to 1 per cent of the total domestic-animal population, and in 10 counties the infestation ranged from 1 to 2 per cent which is consid red moderate to heavy. The infestation generally was fairly well controlled, because veterinarians, county agents, and especially the livestock owners, did a splendid job, all coordinating their efforts in an attempt to eradicate the pest.

As a result of the heavy losses suffered by the livestock owners in South Dakota, State officials and representatves of livestock organizations called meetings of officials from all the North Central States at Omaha, for the purpose of establishing ways and means to stop the interstate transportation of screw-worm-infested animals into those States, which otherwise would never become infested. It is hoped that these timely conferences will result in establishing effective ways and means for preventing the interstate shipment of screw-worm-infested animals into the North Central States. All those States have suffered unnecessarily and heavily during recent years.

The screw-worm survey, through the education and help it has given the livestock owners in the North Central States, has saved many valuable domestic animals and has paid for itself many times over in the good work it has done in those States alone.

Brussels Sprouts Seed Loss in California Caused by the Cabbage Seed Pod Weevil

ELMER C. CARLSON, W. HARRY LANGE, JR. and R. H. SCIARONI[1]

The cabbage seed pod weevil, *Ceutorhynchus assimilis* (Paykull), was first reported in the United States by Baker (1936), and was collected in May, 1935 in Whatcom County, Washington. It spread rapidly through the cruciferous seed producing area of Northwest Washington and has caused considerable seed loss for many years there and later in Oregon and Idaho. However, it was not recorded from California until Hagen (1946) reported it as the turnip seed weevil. His first collection was on March 6, 1946 from the flowers of the common yellow mustard, *Brassica compestris* Linn. in the hills directly behind the University of California campus at Berkeley. Additional specimens were collected during March and April in nearby localities and 1 mile north of Montara in San Mateo County. Unconfirmed reports indicate it was present in Santa Clara County during 1946 and it was definitely present in cauliflower seed crops at Warm Springs, Santa Clara County during 1948.[2] No extensive economic damage was reported until 1949.

The Brussels sprouts seed production of San Mateo County is not a major industry. For the most part it consists of small, scattered plantings. The annual production amounts to approximately 500 to 700 pounds of seed. However, in the past this seed has sold for about 10 dollars a pound, and the local production has been sufficient to plant 1750 to 2000 acres of Brussels sprouts within the county. Furthermore, the seed is well adapted to this particular area and is not replaceable by any other strain or variety known or grown in any other locality at this time. Consequently, the establishment of the cabbage seed pod weevil and the subsequent seed loss has threatened the survival of this industry. In 1949 this insect drastically reduced the production of Brussels sprouts seed. This loss has made the seed difficult to obtain and more expensive.

The authors found the cabbage seed pod weevil causing extensive damage to developing Brussels sprouts seed pods in May, 1949.[3] At the time of these observations the majority of seed plantings already had a high percentage of pod set. However, it was suggested that a benzene hexachloride dust containing 1 per cent of the gamma isomer be applied. This program was initiated by four of the five growers contacted, and they applied two to four dustings to

[1] Principal Laboratory Technician and Assistant Entomologist, University of California, Davis; and, Farm Advisor, San Mateo County, Respectively.

[2] Specimens received from G. W. Scott of Associated Seed Growers and W. R. Corrin, Farm Advisor, Santa Clara County.

[3] Determined by H. H. Keifer.

Table 1.—Cabbage seed pod weevil damage to Brussels sprouts seed as determined by examining 50 pods from each of five fields in San Mateo County, California; on June 9, and 18, 1949

Field Number	Dust Applied	Number of Applications	Per Cent Pods Infested	Number of Larvae per Infested Pod	Seed Count		Per Cent Seed Loss
					Good	Destroyed	
			Half Moon Bay				
1	Lindane, 1%	2	76.0	1.65	575	335	36.8
2	Parathion, 2%	2	68.0	1.60	532	247	31.7
3[1]	Lindane, 1%	3	42.0	1.42	767	131	14.4
			Pescadero				
1	Technical benzene hexachloride, 1% gamma isomer	2	56.0	1.60	713	220	23.5
2[1]	Technical benzene hexachloride, 1% gamma isomer	4	26.0	1.0	845	68	7.4

[1] Seed pod set had started in these two fields but was not as far advanced as in the case of the other fields.

their seed plantings. Past experience has shown that the first application should be made immediately after seed pod development has started and repeated every 10 to 12 days during the duration of pod set; generally this means four to five applications beginning about the last of April and ending by the middle of June. Since pod development was well advanced in all but one or two seed plantings observed, good control was not expected.

The extent of damage and the value of insecticidal applications were determined by collecting random samples of pods on June 9 and 18. The samples were collected from three growers in the Half Moon Bay area and two growers in the Pescadero area. All the Half Moon Bay seed plantings were located within an area of 1 square mile just north of town, while the two Pescadero fields were within 1 mile of each other just west of town.

The results of these counts demonstrated the extensive seed loss caused by the cabbage seed pod weevil in San Mateo County in 1949. They also showed that chemical control was not obtained in the seed plantings where pod set was well advanced before dust applications were begun. Fair control was obtained in field number three of the Half Moon Bay area with one per cent lindane dust. In this case three applications reduced the seed loss from about 30 per cent to about 14 per cent. Fair to good control was obtained by means of four applications of one per cent technical benzene hexachloride in one of the Pescadero fields. In this case a seed loss of only 7.4 per cent was sustained. The damage counts are summarized in table 1.

During these investigations and observations no evidence of natural parasitism was observed. The major parasites of the Pacific Northwest, *Trichomalus fasciatus* Thoms. and *Necremnus duplicatus* Gahan, have apparently not become established with the weevil in this particular area.

The damage incurred to Brussels sprouts seed by the cabbage seed pod weevil and its rapid spread in the state indicate that in the future this species may also become an important pest in the larger California cruciferous seed producing areas.

Literature Cited

Baker, W. W. 1936. Notes on a European Weevil, *Ceutorhynchus assimilis* Paykull., recently found in the state of Washington. The Can. Ent. **68**(9): 191–3.

Hagen, K. S. 1946. The occurrence of *Ceutorhynchus assimilis* (Paykull), in California. Pan Pac. Ent. **22**(4): 73.

Unpublished Data of George Ware Barber on the House Fly[1]

Eleanor B. Starnes,[2] *New Jersey Agricultural Experiment Station*

Because of increasing interest in resistant strains of the housefly, *Musca domestica* L., the following material is offered as a brief review of part of the unpublished data of the late G. W. Barber. Twenty-one separate strains of the housefly were studied in minute detail. Two strains were maintained for only three generations while others were in the fifty-fifth generation in June, 1949 when these observations were terminated. Each line of flies was maintained separately. A minimum of three jar cultures (about 6000 puparia) was reared for each strain each generation. Each jar culture of pupae was washed, dried and sorted into six distinct classes according to pupal shape (1). After the pupae were classified they were weighed in lots of 100. The culture which was chosen to become the generation culture was placed intact in a rearing cage. Pupae from other cultures of the same generation were set aside to emerge. Counts were kept of the numbers of flies emerging, partly emerging and not emerging. Generation cages were selected on a basis of uniformity of pupal size—pupae weighing 2 grams per hundred were chosen for generation cages whenever possible.

Not all strains of flies contained all six pupal forms. In strains where dentical pupal forms occurred the percentage of one form in one strain did not coincide with the percentage of the same form in the second strain. Of the 21 strains examined three displayed some degree of resistance to chemical test, the most important being the Ellenville. Three strains were found to be extremely susceptable to insecticides.

By December, 1947 over three million pupae had been examined. This number will be considerably increased by the time the remaining 18 months data are compiled. A summary of each of the 21 lines will be made available as soon as the remaining data can be correlated.

Literature Cited

Barber, G. W. 1948. The lethal lines of the house fly. Jour. Econ. Ent. **41**(2): 292.

[1] Research carried out in part with funds provided by the Office of the Quartermaster General, Department of the Army.

[2] Graduate fellow with the Quartermaster project, now with Geigy Co., Inc., Research Laboratory, Bayonne, N. J.

Influence of Sound Kernels Compared with Halved Kernels of Wheat upon Oviposition of the Rice Weevil

D. Bap Reddy, *University of California, Berkeley*

It has been reported that the rice weevil, *Sitophilus oryzae* (L.), prefers to lay eggs in sound grain. This is not only important in revealing the behavior of the weevil but also is useful in other respects. The number and distribution of eggs and the oviposition site may depend upon the condition of the grain present. Therefore, in the present investigation experiments were conducted to determine what influence the condition of the grain might play in the oviposition of the rice weevil.

Experimental Methods.—White Federation wheat of uniform size in equilibrium with 77 per cent relative humidity was used in all the experiments. With a sharp scalpel a portion of it was halved crosswise, separating the two ends. It was calculated that the surface area of one sound kernel was approximately one and one-half times that of a halved kernel. Whole, as well as the halved kernels of wheat were placed horizontally, the suture of the kernel facing the bottom of the rearing jars. Each series of tests were run in triplicate and the amount of grain used in each test of the series was as follows: Series 1, 100 sound kernels; series 2, 100 halved kernels; series 3, 120 sound kernels; series 4, 240 halved kernels; series 5, 50 sound and 50 halved kernels; series 6, 60 sound and 90 halved kernels, and series 7, 60 sound and 120 halved kernels. Series 1, 2, 3 and 4 were set up in separate culture bottles. Series 1 and 2

were based on equal numbers and 3 and 4 on a basis of equal weight. Series 5, 6 and 7 were based on equal numbers, equal surface area and equal weight respectively.

The sexes in the adult rice weevil can be distinguished by differences in the length, width and the punctures of the rostrum. The female rostrum is longer, narrower and more curved than that of the male and the punctures are less conspicuous. Adult females were secured from a single day oviposition culture and in no case were older than 2 months. Ten females were introduced into each culture bottle and were removed after 48 hours.

All the experiments were carried out at a constant temperature of 30° C. and 77 per cent relative humidity.

Because the eggs are laid inside the grain, dissection is necessary to determine the exact number of eggs. Different methods can be used to detect the egg-plug on the grain. The method of Frankenfeld (1948) which involves the use of acid fuchsin in a solution of glacial acetic acid and distilled water was used in these experiments. This dye was very satisfactory and almost all the egg-plugs treated stained a cherry red colour. Treated kernels were dissected and the eggs were located and counted.

RESULTS.—The results obtained showed that in all cases where sound and halved kernels were given to weevils in a mixture, females laid more eggs in sound than in halved kernels. When sound and halved kernels were offered separately in equal numbers females laid more or less the same number of eggs in each culture. But when the number of sound kernels was only half as many as that of the halved kernels females laid more eggs in cultures containing the halved kernels.

Table 1.—Oviposition of the rice weevil in sound kernels as compared to halved kernels of wheat at a constant temperature of 30° C. and a relative humidity of 77 per cent.

COMPOSITION OF THE MIXTURE OF SOUND AND HALVED KERNELS	AVERAGE NUMBER OF EGGS LAID BY 10 FEMALES IN 48 HOURS	
	Sound Kernels	Halved Kernels
Equal numbers	32.3	10.6
Equal surface areas	21.3	7.6
Equal weights	21.0	10.6

The preferential oviposition of the rice weevil in sound as compared to halved kernels is shown in table 1. In all mixed cultures of sound and halved kernels, whether based on equal numbers, equal surface area or equal weight, more eggs were laid in sound than in halved kernels. Where the kernels were mixed on the basis of equal numbers or equal surface area, the number of eggs laid in sound kernels was three times greater than that laid in halved kernels. The number of eggs laid in sound kernels was approximately two times greater than the number laid in halved kernels when both were presented to weevils in a mixture on the basis of equal weight. This indicates that females preferred to lay eggs in sound rather than in halved kernels when they were given a free choice.

It was found that approximately equal numbers of eggs were laid near both ends of the wheat kernels although female weevils showed a slight preference for the stigmatic end. This was true in all cases, whether whole kernels, halved kernels or a mixture of the two were offered in separate jars. Very few eggs were laid in the cut end of the halved kernels, and a very small number was found on the middle portion of the sound kernels. Therefore, the chance of accessibility of the surface of the kernel for oviposition was almost equal in the case of both the whole and the halved kernels of wheat. Hence, it can be assumed that the position of the kernel in the culture jar did not influence the preferential oviposition of the rice weevil.

CONCLUSIONS.—The preference for egg laying in sound grain is not due to the differences in the moisture content, number of each kind present, weight, equal surface area nor can it be accounted for by the grain's becoming unsuitable for oviposition due to being already infested.

The possibility of the differences in the chemical constitution can be disregarded because all the wheat used was of one variety.

The female rice weevil showed a preference to lay eggs in sound kernels only when sound and halved kernels were presented simultaneously and a choice was possible. The factors involved in this preference are not known definitely but it is possible that the size of the kernel played a greater role than the condition or the accessibility of the surface of the wheat kernels.

ACKNOWLEDGMENTS.—Grateful acknowledgments are made to Dr. A. E. Michelbacher for his guidance and assistance during the investigation. Gratitude is expressed to Professor E. O. Essig, Chairman of the Division of Entomology and Parasitology, for his help and provision of the facilities.

LITERATURE CITED

Frankenfeld, J. C. 1948. Staining methods for detecting weevil infestation in grain. U.S.D.A. ET-256.

A New Insecticide to Control Turf Insects

J. B. POLIVKA, *Ohio Agricultural Experiment Station, Wooster*

The complex chlorinated hydrocarbon known as heptachlor[1] was used experimentally for the first time in Ohio in 1949 for the control of turf inhabiting insects.

An experiment on the control of grubs, especially Japanese beetle larvae, was established in June of 1949, using 4 levels of heptachlor at 1, 5, 10, and 20 pounds of the technical material per acre. All plots, which were replicated five times, consisted of 100 square feet with the dimensions 10 by 10 feet. To simplify the distribution, the amount of toxicant necessary for a single plot was mixed thoroughly with 2 pounds of milorganite and broadcast with a fertilizer spreader. The data in table 1 were obtained by examining three one-third square foot samples in each plot on September 19, 1949.

All levels of heptachlor gave excellent control of the grubs found in this area. The grass in the untreated plots was brown and the turf was full of holes made by birds feeding upon the larvae.

Early in September of 1949 the annual white grub, *Cyclocephala borealis* Arrow, was found abundant in

[1] The empirical formula of the heptachlor is $C_{10}H_5Cl_7$.

Table 1.—Control of grubs in turf by means of heptachlor. Data taken 3 months after treatment.

Amount of Actual Toxicant per Acre in Lbs.	Grub Population per Square Foot (Mean of 5 Replicates)			
	Popillia japonica	*Cyclocephala borealis*	*Phyllophaga* spp.	Total
1	.2	.0	.0	.2
5	.0	.0	.0	0
10	.0	.0	.0	0
20	.0	.0	.0	0
Untreated	18.2	2.2	.8	21.2

several areas in the state. In some golf courses it caused complete destruction to large blocks which included the fairways as well as the roughs.

On September 12, heptachlor was included in an experiment with other insecticides to determine their relative effectiveness for the control of this insect. All toxicants were used at a single level to plots of 1120 square feet with each treatment replicated four times. All plots were sampled October 10, 1949, by taking 3 one-third square foot samples in each plot. The data are shown in table 2.

Table 2.—Comparative effectiveness of heptachlor and other insecticides in controlling *Cyclocephala borealis* Arrow from data taken October 10 following treatment September 12.

Toxicant	Rate of Technical Material in Lbs. per Acre	Population per Sq. Ft. (Mean of 4 Replicates)	Per Cent Reduction in 28 Days
Heptachlor	10	2.0	75.0
Aldrin	10	2.8	65.0
DDT	25	5.3	33.7
Chlordane	10	5.3	33.7
Lead arsenate	500	5.5	31.2
Toxaphene	25	6.8	15.0
Parathion	5	3.8	52.5
Benzene hexachloride	5	3.8	52.5
Dichlorodiphenyl dichloroethane	25	11.8	.0
Untreated		8.0	
Least significant difference at the 5% level		4.0	

All toxicants, except dichlorodiphenyl dichloroethane, caused considerable reduction of the larvae per square foot in 1 month. However, heptachlor, aldrin, parathion, and benzene hexachloride were the only materials that were significantly better than the check at the end of this period. These plots will be sampled for grub population at later dates to determine residual toxicities.

Summary.—Three months after treatment heptachlor was found to be very effective against the larvae of the three types of grubs found in the experimental area when used at rates as low as 1 pound per acre.

Nine toxicants were applied to turf as soil insecticides for the control of grubs of *Cyclocephala borealis* Arrow. These materials were applied in the dry stage and at varying rates of the active ingredient.

The lowest population records were observed in the plots treated with heptachlor. At the end of 28 days plots treated with heptachlor, aldrin, parathion and benzene hexachloride were significantly better than the untreated plots but were not significantly different from the chlordane, DDT, toxaphene, or lead arsenate plots. Dichlorodiphenyl dichloroethane did not show any promise as a soil insecticide in this short time.

Spinose Ear Tick in Florida

Andrew J. Rogers[1] and T. W. Mills[2]

On March 28, 1949, an argasid tick was collected from the ear of a grade Hereford calf by the junior author and was identified as the spinose ear tick, *Otobius Megnini* Meig. The animal from which this specimen was taken had been dipped the previous day but the tick was apparently not affected by the dip. The specimen, which was a nearly engorged nymph, was sent to Dr. F. C. Bishopp, Assistant Chief, Bureau of Entomology and Plant Quarantine, who verified our identification.

Bishopp & Trembley (1945) record an infestation of this species at Orlando, Florida, in 1912 on horses shipped from New Mexico during the previous year. This is the last published record known to the authors of this paper of this species occurring in Florida and it is assumed that the Orlando infestation failed to become established. In a letter to us dated May 6, 1949, Dr. F. C. Bishopp states that the Bureau of Entomology and Plant Quarantine has no additional records of this tick from Florida. In a letter of May 21, 1949, Dr. J. V. Knapp, Veterinarian, Florida Livestock Sanitary Board, stated that specimens of this tick had come to his attention from time to time, these being taken from shipments of cattle originating in Texas, but that our record was the first to his knowledge from Florida cattle.

The specimen collected at Gainesville this year was traced to a herd in Alachua, Florida. Our first visit to this herd was April 11, 1949, but due to the owner being temporarily absent from the state only one animal could be examined. This was a young calf that was in the barn. This calf had two partially engorged nymphs in its ears.

On May 16, after the owner had returned, approximately 15 cows and calves were examined. Nine nymphs in various stages of engorgement were collected from these animals. One larva was collected from the ear of a dog the same date. One bull and seven cows and calves were examined November 11. Three nymphs were taken from the bull and the cows and calves were negative. An examination of the barn, corral, watering areas, salt boxes, trees, and fence posts on this same date yielded only one specimen. This was an adult tick found by probing into a crack in a feed bin in the barn. A nymphal skin was also collected from the same place.

The owner of the herd has been using control measures since May 16 and this probably accounts for the smaller numbers of ticks collected from the cattle on November 11.

Statements by the owner concerning the history of his herd strongly indicate that this infestation has existed for almost 7 years, or since 1943. The present herd was established that year by importing two carloads of cattle from Texas, one from Georgia, and one from Tennessee. Since the tick is not known to be established in the latter two states and since it is native to the southwestern United States, it is

[1] Assistant Professor of Entomology, University of Florida.
[2] Student, Department of Entomology, University of Florida.

reasonable to assume that it was introduced on the Texas cattle.

Whether or not the tick will be able to maintain itself here permanently will, of course, have to be determined at a later date. An encouraging factor in regard to this is the fact that it has probably been introduced many times, in the manner described above, since the Orlando infestation in 1912, apparently without becoming established. It seems unlikely that it would be overlooked during this long period. However, the tick does appear to be well established in the Alachua herd.

There is not much information to date relative to the possible spread of the tick from the Alachua herd. Several attempts have been made to examine herds located nearby but unfortunate circumstances have prevented this to date. Several herds in the Gainesville area have been sampled and found negative. An encouraging factor relative to the intrastate distribution is the fact that the owner states that he has not sold cattle locally, nor have any been shipped to other areas of the state, with the exception of the lot that was sent to the Gainesville Livestock Market in March to be dipped. This lot was destined for a northern state. He stated that all other sales have been to packers and that the shipments have been out of the state.

The authors are hoping to make a more complete survey of surrounding herds in the near future. In the meantime it is planned to work closely with the owner of the infested herd in an effort to eradicate the tick there.

LITERATURE CITED

Bishopp, F. C., and Trembley, Helen Louise. 1945. Distribution and Hosts of Certain North American Ticks, Journal of Parasitology, **31**(1): 1–54.

Relative Toxicity to House Flies of DDT, Methoxychlor, and Dichlorodiphenyl Dichloroethane

R. H. NELSON, W. A. GERSDORFF, and NORMAN MITLIN, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Two of the analogs of DDT that are in commercial production as insecticides are methoxychlor and dichlorodiphenyl dichloroethane (TDE). Chemically, methoxychlor is 1,1,1-trichloro-2,2-bis(*p*-methoxyphenyl)ethane, and TDE is 1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethane. Comparison of these names with the designation of DDT—1,1,1-trichloro-2,2-bis(*p*-chlorophenyl)ethane—indicates the structural differences between the compounds.

The studies that are reported here were undertaken to determine the relative toxicity to house flies, *Musca domestica* L., of these two analogs as space sprays in comparison with DDT. No attempt was made to evaluate residual efficiency. Chemically pure compounds were used in all tests. Their molecular weights are as follows: TDE 320.1, methoxychlor 345.7, and DDT 354.5.

PREVIOUS WORK.—Busvine (1946) studied these compounds, among others, and obtained median lethal concentrations for various insects. Against body lice, *Pediculus humanus corporis* Deg., methoxychlor and TDE were of equal effectiveness but were only one-third as toxic as DDT. Against bed bugs, *Cimex lectularius* L., methoxychlor was equal to DDT, whereas TDE was about one-half as effective. Methoxychlor was also the more toxic of the two analogs to yellow-fever mosquitoes, *Aëdes aegypti* (L.), but was not equal to DDT.

Deonier *et al.* (1946), working with the larvae of the common malaria mosquito, *Anopheles quadri-*

Table 1.—Relative toxicity to house flies of DDT, methoxychlor, and TDE in kerosene space sprays. Means of seven replicates with approximately 100 flies to each test.

MATERIAL	CONCENTRATION	KNOCK-DOWN IN 25 MINUTES	MORTALITY IN 1 DAY	CONCENTRATION CAUSING 50 PER CENT MORTALITY	RELATIVE TOXICITY AT 50 PER CENT MORTALITY LEVEL
	Mg. per ml.	*Per cent*	*Per cent*	*Mg. per ml.*	
DDT	1.00	49	95	0.361 ± .037	1.0
	.667	37	83		
	.444	20	58		
	.296	42	43		
Methoxychlor	1.50	100	82	0.603 ± .062	0.60
	1.00	99	72		
	.667	98	52		
	.444	69	40		
TDE	2.25	95	68	1.43 ± .15	0.25
	1.50	90	59		
	1.00	65	27		
	.667	62	16		
"Pyrethrins"	8.00	100	80	2.44 ± .49	—
	4.00	100	64		
	2.00	100	42		
	1.00	100	28		

maculatus Say, found the median lethal concentrations of DDT and TDE to be approximately equal and about one-fourth of that of methoxychlor.

Metcalf (1948) found TDE to be about one-sixth and methoxychlor one-thirtieth as toxic as DDT in residual tests against the greenhouse thrips, *Heliothrips haemorrhoidalis* (Bouché). However, these two analogs were about equally toxic to the citrus red mite, *Paratetranychus citri* (McG.), and both were appreciably more effective than DDT.

Lord (1948) found methoxychlor and TDE (neither so called by him) to have, at the 50 per cent kill level, approximately equal contact potency against the chrysanthemum aphid, *Macrosiphoniella sanborni* (Gill.), and to differ little against the saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.). At this kill level the potency of DDT was about four times that of the analogs against the aphid and approximately three times as great against the grain beetle. The probit regression lines obtained were not parallel; hence these relative potency figures do not hold at other mortality levels. Lord concluded that the toxicity of DDT analogs appears to be related to molecular weight, with maximum toxicity in the range 300 to 450.

Lehman (1949) published the following estimated fatal doses to humans: DDT 30 gm., methoxychlor 450 gm., and TDE 300 gm. These figures were interpreted from animal experimentation.

PROCEDURE.—The comparisons in this paper are based on measurements determined by the Campbell turntable method. The flies were reared and the adults fed according to standard procedure for this method. Flies were used for testing on the second or third day after emergence. Preliminary tests were run to determine a range of concentrations on a weight-volume basis that would span the 50 per cent mortality point for each compound. The usual pyrethrum standard, prepared from a newly prepared commercial 20 per cent extract in kerosene, was included. Of the total "pyrethrins," 54 per cent was pyrethrin I and cinerin I. All test samples were made up in deodorized kerosene.

Approximately 100 flies were used per test, and seven replications were run at each concentration. Knock-down and mortality percentages were determined, and the mean values are given in table 1.

The figures for mean concentration causing 50 per cent mortality were obtained by plotting the concentration-mortality data on log-probability paper and reading the 50 per cent points from the regression lines. Standard errors of these means were obtained by analysis of variance of the logarithms of the daily estimations. The standard errors of the mean concentrations were then determined from those of the logarithms. Relative toxicity values were computed on the basis of these LD 50 concentrations.

The relative-toxicity ratios presented in table 1 were obtained with DDT as the standard of comparison. Pyrethrum-extract sprays are commonly used for this purpose, but in the present studies the primary purpose was comparison of the synthetic compounds. The toxicity data for the "pyrethrins" are of interest only as an indication of the vigor of the flies. Incidentally it was observed that results with the synthetic compounds were more readily reproduced than those with the "pyrethrins" and that the slope of the regression line for the latter was the lowest in value of the four materials.

RESULTS.—Methoxychlor demonstrated a high knock-down potential, in agreement with published information (Prill *et al.* 1945). TDE had greater knock-down effect than DDT. The initial paralysis caused by these synthetic compounds is not equal to the complete immobilization that results from pyrethrum sprays.

The relative-toxicity figures at the 50 per cent mortality level show methoxychlor to be about three-fifths and TDE approximately one-fourth as toxic as DDT. Since these three compounds do not have greatly different molecular weights, it follows that on a molecule-to-molecule basis they are of about the same relative potency against house flies as was determined from the weight-volume data.

LITERATURE CITED

Busvine, J. R. 1946. Insecticidal tests with analogues of DDT. Soc. Chem. Indus. Jour. [London] **65:** 356–60.

Deonier, C. C., H. A. Jones, H. L. Haller, E. Hinchey, and H. H. Incho. 1946. Mosquito larvacide tests—A resume of tests of compounds related to DDT against larvae of *Anopheles quadrimaculatus*. Soap and Sanit. Chem. **22**(11): 118, 119, 139.

Lehman, A. J. 1949. Pharmacological considerations of insecticides. Assoc. Food and Drug Off. of U. S. **13**(2): 65–70.

Lord K. A. 1948. The contact toxicity of a number of DDT analogues and of four isomers of benzene hexachloride to *Microsiphoniella sanborni* and *Oryzaephilus surinamensis*. Ann. Appl. Biol. **35**(4): 505–26.

Metcalf, R. L. 1948. Acaricidal properties of organic compounds related to DDT. JOUR. ECON. ENT. **41**(6): 875–882.

Prill, E. A., A. Hartzell, and J. M. Arthur. 1945. Insecticidal activity of some alkoxy analogs of DDT. Science **101**(2627): 464–5.

Control of the Iris Whitefly on Potatoes

K. E. GIBSON and B. J. LANDIS, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[1]

The iris whitefly, *Aleyrodes spiraeoides* Quaint., is an annual pest of late-crop potatoes grown under irrigation in the Yakima Valley, Washington. Enormous numbers of whiteflies may develop in non-treated fields of potatoes in August and September (Landis & Getzendaner 1947).

In 1948 the feeding of these insects appeared to be responsible for a loss of plant vigor in some fields. Therefore, preliminary information on the control of the whitefly on potatoes was obtained by recording the surviving whiteflies in experiments conducted at Toppenish, Wash., on multiple applications of insecticides for the control of aphids. In August the effectiveness of single applications of dusts and sprays was observed at Zillah, Wash., in a potato field heavily infested with whiteflies.

MATERIALS AND METHODS.—The following dust mixtures were prepared by diluting commercial concentrates with pyrophyllite. DDT-nicotine dust mixtures were prepared from a 50 per cent DDT wettable powder and a 14 per cent nicotine dust. Ditolyl trichloroethane dust was made from a 25 per cent dust base. Benzene hexachloride dust was prepared

[1] In cooperation with the Washington Agricultural Experiment Station.

Table 1.—Effectiveness of multiple applications of insecticide dusts against the iris whitefly on Netted Gem potato leaves. Toppenish, Wash., 1948.

Insecticide	Dosage per Acre Application	Average Number of Whiteflies per 25 Compound Leaves			
		Eggs	Larvae and Pupae	Adults	All Stages
	Pounds				
Experiment 1 (5 applications, June 6 to July 28)					
DDT:					
10%	25	6.6	2.3	0.6	9.5
5%	24	11.5	2.1	1.1	14.7
5%, nicotine 1%	21	13.1	0.7	0.9	14.7
5%, tetraethyl pyrophosphate 1%	14	19.1	1.9	1.2	22.2
Difference required for significance (P=5%)		5.5	—[1]	—[1]	6.6
Experiment 2 (3 applications, June 8 to July 7)					
DDT 5%, nicotine 3%, sulfur 37%	40	14.2	1.9	1.1	17.2
Toxaphene 10%	37	11.3	2.2	0.9	14.4
Ditolyl trichloroethane 5%	39	14.5	2.5	1.0	18.0
Difference required for significance (P=5%)		—[1]	—[1]	—[1]	—[1]

[1] Not significant by the *F* test.

from a dust base containing 25 per cent of the gamma isomer and 8.3 per cent of other isomers. The other dust mixtures were commercial products.

DDT-emulsion spray was prepared from a commercial product reported to contain 25 per cent of DDT, an alkyl naphthyl ether solvent, and an emulsifying agent. DDT-suspension spray was made from a 50 per cent DDT wettable powder. Chlordane emulsion was made from technical chlordane, xylene solvent, and a sodium alkyl sulfate emulsifying agent.

There were two experiments at Toppenish in which multiple applications were made with large row-crop dusters on plots at least 200 feet long and 12 rows wide. At Zillah single applications were made with hand dusters or sprayers on plots 25 feet long and 3 rows wide. In each of these experiments there were four replicates in randomized blocks.

In the small plots the middle row was used in sampling the whitefly populations. In the multiple-application tests the relative effectiveness of the insecticides was determined by counting the numbers of whitefly eggs, larvae, pupae and adults on 25 compound leaves taken at intervals along one of the center rows. Population counts were made after each insecticide application, and repeated at approximately 10-day intervals. In the single-application tests, eggs and larvae were counted before and after treatment. They were so numerous, however, that it was not practical to make counts on 25 entire compound leaves per plot. Sections 0.81 inch in diameter were cut out of 50 leaflets picked from each plot. The total area in samples from each treatment amounted to 104 square inches. The insect counts were made immediately before and 1 and 2 weeks after application.

Multiple Applications.—Results of multiple-application tests are shown in table 1. In the first experiment a 10 per cent DDT dust was better than a dust containing 5 per cent of DDT plus either 3 per cent of nicotine or 1 per cent of tetraethyl pyrophosphate in preventing the whitefly from laying eggs.

Table 2.—Effectiveness of single applications of insecticides tested against the iris whitefly on Netted Gem potatoes. Zillah, Wash., 1948. Counts were made on 104 square inches of leaf surface.

Insecticide	Dosage per Acre	Larvae		Eggs	
		Before Treatment	Reduction After 2 Weeks	Before Treatment	Reduction After 2 Weeks
	Pounds	*Number*	*Per cent*	*Number*	*Per cent*
Dusts:					
DDT: 5%	88	1441	19	2422	92
DDT 5% plus tetraethyl pyrophosphate 1%	92	1060	39	1977	91
DDT 4% fused with sulfur	104	965	20	1878	93
Parathion 1%	120	1269	45	2721	87
Benzene hexachloride 1%	128	903	—[1]	2569	36
Sprays:[2]	*Gallons*				
DDT 2 lbs.:					
Emulsion	114	1009	9	2051	77
Suspension	142	1190	6	1883	75
Chlordane 1 lb., emulsion	125	966	—[3]	1992	10

[1] The number of larvae increased 110 per cent.
[2] Amounts of the technical material in 100 gallons of spray.
[3] The number of larvae increased 62 per cent.

DDT-tetraethyl pyrophosphate dust was the least effective, probably because the dosages applied were comparatively light. Moreover this mixture was wet and difficult to apply at the desired rate. The 10 per cent DDT dust was also effective against the adults.

In the second plot experiment, differences in infestation were within the limits of experimental error, and there were no significant differences in population between any of the treatments.

An entire field was dusted with a mixture containing 5 per cent of DDT and 0.5 per cent of tetraethyl pyrophosphate at the rate of 18 pounds per acre-application. Six applications were made between June 12 and August 14. There were fewer eggs and adults in this field than in any of the multiple-application tests, but there were a few more larvae than in plots of experiment 1 that were dusted with the DDT-nicotine mixture.

In another field promising results were obtained against adults of the whitefly with seven weekly applications of a dust containing 1 per cent of parathion, at the rate of 84 pounds per acre-application. Seven applications were made between May 17 and June 28.

SINGLE APPLICATIONS.—Results of tests with single applications, in the third experiment, are shown in table 2. Insecticides had little effect on larvae within the first 2 weeks, but the DDT and parathion dusts reduced the egg populations from 87 to 93 per cent as a result of adult mortality. Benzene hexachloride dust and chlordane sprays were not effective. DDT sprays were less effective than DDT dusts.

These results are in general accord with those of Hill & Sooter (1946), who found that benzene hexachloride was ineffective against a species of whitefly infesting potatoes in Nebraska, whereas DDT gave excellent control.

LITERATURE CITED

Hill, Roscoe E., and C. A. Sooter. 1946. Potato insects. Tests with 666 and DDT. Nebr. Agr. Expt. Sta. Ann. Rept. **60**: 50–1.

Landis, B. J., and C. W. Getzendaner. 1947. **Aleyrodes spiraeoides** infesting potatoes. JOUR. ECON. ENT. **40**(4): 567.

Potato Tuberworm Control in Southern California[1]

LAUREN D. ANDERSON and HAROLD T. REYNOLDS[2]
University of California Citrus Experiment Station, Riverside

In July, 1948, in the Lakeview area of Riverside County, approximately 200,000 bags of government price support potatoes were spread over 30 or more acres of ground for dehydration into hog food. Owing to the depth of the spread potatoes (2 to 10 inches), dehydration was slow. As a result, excellent breeding conditions were provided for the potato tuberworm, *Gnorimoschema operculella* (Zeller), and for flies, which increased to tremendous numbers by September.

Potato tuberworm moth migration from the dump was heavy, particularly in the direction of the prevailing wind. Potato fields as much as 1 or 2 miles down wind became heavily infested. Insecticide tests were started on September 14, 1948, in a potato field located about one-quarter mile down wind from the dump. This field was heavily populated with potato tuberworm larvae, which were mining into the potato foliage and stems. In fact, the infestation was so severe that it threatened to kill the plants in a short time.

In view of the tuberworm control reported by Hofmaster & Anderson (1948) and by Lloyd (1946) with recently developed insecticides, the following treatments were used for comparison: 5 per cent DDT, 5 per cent dichlorodiphenyl dichloroethane, 10 per cent toxaphene, 5 per cent chlordane, and 1.5 per cent lindane.

These insecticides were applied as dusts by a ground duster at approximately 40 pounds per acre. The first application was made on September 14 with a duster, using two nozzles to a row. The second application was made on September 20 with a duster using one nozzle to a row. Five large nonreplicated blocks were treated, and a small area was left untreated.

Sampling was accomplished by examination of

[1] Pacific Slope Branch Program, 1949.

[2] The authors are indebted to James W. Hashe for his valuable assistance in this project.

Table 1.—Effect of various insecticide dusts on potato tuberworm control in field plots given duplicate applications—one on September 14 and the other on September 20, 1948.

TREATMENT	TUNNELS (PER 100 EXAMINED) CONTAINING LARVAE			PER CENT CONTROL OVER CHECK
	After First Treatment[1]		Alive After Second Treatment[2]	
	Alive	Dead	None	
Lindane, 1.5%	1	72	27	none	100
Toxaphene, 10%	13	36	51	1.0	98.5
Dichlorodiphenyldichloroethane, 5%	10	25	65	1.5	97.8
DDT, 5%	13	25	62	2.0	97.1
Chlordane, 5%	47	23	30	21.5	69.0
Check	77	2	21	69.5	—
Difference required for significance (19:1 odds)	13.5	16.8	15.0	2.8	

[1] 100 tunnels per treatment, examined on September 17, 1948.
[2] 200 tunnels per treatment, examined on September 22, 1948.

tuberworm tunnels in the potato leaves and stems. Counts were replicated in each block, and results were analyzed by Fisher's analysis of variance. On September 17, 33 tunnels were examined in each of two replicates, and 34 tunnels were examined in the third replicate, for a total of 100 tunnels examined for each treatment. In this count the tunnels were classified as empty or as occupied by larvae. If the tunnels contained larvae, notation was made as to whether they were dead or alive. On September 22, 50 tunnels were examined in each of four replicates for a total of 200 tunnels examined for each treatment. In this count, records were taken only on live tuberworm larvae in the tunnels. The results of these two counts are summarized in table 1.

In this experiment lindane gave a quick and excellent kill. The speed of kill was evident on the third day after treatment, by the large number of dead larvae remaining in the tunnels. The materials other than lindane were considerably slower in their action, and most of the larvae escaped from the tunnels before dying. By the time of the second treatment, DDT, dichlorodiphenyl dichloroethane, toxaphene and lindane gave 97 to 100 per cent control of the tuberworm larvae. Chlordane (69 per cent control) was significantly poorer than the other treatments but it was significantly better than no treatment.

At digging time, on December 8, potato tubers were examined from all plots, and no tuberworm injury could be found. In addition, raw potatoes were peeled and tasted in the field for evidence of off-flavor. A definite change in flavor was apparent in the lindane-dusted potatoes when compared with those from other treatments. As a result of this field-taste test, potatoes from the check and lindane plots were numbered and given to 20 individuals for cooking. None of the samplers knew which potatoes were from which treatment. In each case the two samples were cooked separately and reported by the assigned number. Seven (35 per cent) of the samplers reported the potatoes from the lindane-dusted plot as having a different flavor; 65 per cent of the samplers reported no difference. Of these seven people, only one considered the flavor objectionable.

SUMMARY.—Insecticide dusts were applied to a potato field in southern California for potato tuberworm control. Two applications at 40 pounds per acre were made at a 6-day interval by ground duster. In this test 5 per cent DDT, 5 per cent dichlorodiphenyl dichloroethane (DDD or TDE), 10 per cent toxaphene, and 1.5 per cent lindane gave 97 to 100 per cent control. Five per cent chlordane was significantly poorer, with 69 per cent control. Lindane gave a quick kill; the other materials were a little slower in their action. At harvest time 35 per cent of the people sampling the potatoes from the lindane treatment reported the tubers to have a slight, though not objectionable, off-flavor.

LITERATURE CITED

Hofmaster, Richard N., and Lauren D. Anderson. 1948. Potato tuberworm control in Virginia. JOUR. ECON. ENT. 41(2): 198–201.

Lloyd, N. C. 1946. Insecticidal control of potato moth. Promising results with DDT. Agr. Gaz. N. S. Wales. 57(5): 229–33.

A Mite Infestation of the Honey Locust

DONALD L. SCHUDER, *Agricultural Experiment Station, Purdue University*

During the summer of 1949 a severe infestation of the mite *Tetranychus ellipticus* Garman,[1] was found defoliating the honey locust, *Gleditsia triacanthos* at Lafayette, Indiana. Following this defoliation the trees leafed out again the latter part of August. The infested leaves presented a dappled appearance due to the pale spots of yellowed tissue caused by the feeding of the mites. The elliptical mites and the pearly, lozenge shaped, eggs were abundant amid the web on the abaxial side of the leaf.

On August 19 a combination spray of parathion and 50 per cent K-6451, *p*-chlorophenyl *p*-chlorobenzenesulfonate,[2] a new acaracide was applied to the most heavily infested of two trees. One pound of the 25 per cent wettable powder of parathion and one pound of the acaracide were diluted with 100 gallons of water. Five days after this application was made leaf samples were taken at random from the sprayed tree and a neighboring lightly infested tree, undefoliated, which served as a check. All mites were killed on the treated tree, while the untreated tree showed a natural mortality of 37 per cent. On the basis of this preliminary experiment the parathion-acaricide combination appears to be effective against *Tetranychus ellipticus* Garman.

[1] Determined by Edward W. Baker.
[2] *C854*, Dow Chemical Co.

Tests on Elm Scolytus 1949

STANLEY W. BROMLEY, *Bartlett Tree Research Laboratories, Stamford, Conn.*

Tests on the control of elm *Scolytus* were continued in 1949 at the Bartlett Tree Research Laboratories. The same technique was used as that reported by Bromley (1948). Young American elm trees in pots were sprayed, then caged in celluloid, and adults of the European elm bark beetle, *Scolytus multistriatus* Marsh., were introduced into the cages throughout the season of flight of the first brood of beetles.

Two sprays were tested, both in aqueous suspension. One tree was sprayed with toxaphene[1] wettable powder at the rate of 5 lbs. to 100 gallons of water. The second tree was sprayed with methoxychlor at 5 lbs. of 50 per cent wettable powder to 100 gallons. The third tree was left unsprayed as a check but covered with celluloid and adult *Scolytus* introduced.

Introductions of adult *Scolytus* were made every other day from May 18 to July 13 with a total of approximately 1000 live beetles liberated in each cage.

Due to the early season of 1949, emergence of *Scolytus* began about a month earlier than in 1948.

Scolytus-infested bark was secured on November 13, 1948, from a large American elm which had just been felled along one of the streets in Stamford. It had been girdled a thousand times over by *Scolytus* and was practically dead when cut down. This bark was kept exposed to the air in the Insectary during the winter to prevent development of mold and was caged in April 1949. One cage was placed in the sun and one kept in the shade. First emergence in 1949 was from the cage in the sun on May 16 whereas the first emergence from the cage in the shade took place

on May 28. Compare these figures with those of the season of 1948. In 1948, the first *Scolytus* were emerging from the cages on June 11, while the peak of emergence was not reached until July 3.

Emergence peaks in 1949 came on June 1 when 400 *Scolytus* adults came out, June 7 when 450 emerged, June 12 when 600 emerged and June 20 when 425 adult beetles made their appearance. The last date of emergence in 1949 was July 13 when nine beetles were removed from the rearing cage and placed on one of the celluloid-encased trees.

The potted elms were taken from the Insectary on August 4, the celluloid cages removed, and the trees exposed to the weather. All beetles in the cages had been dead several weeks. The elm trees were photographed on October 10, 1949.

RESULTS.—On the untreated tree, girdling was apparent by June 1. The tree appeared to be dying on June 12 but on July 1 two feeble new shoots appeared but these soon wilted and the tree was completely dead on August 1. Death was due to girdling by the *Scolytus* beetles. The number of feeding punctures on this tree was ascertained on October 28, as 42, many of them coalescing.

The toxaphene-sprayed tree showed 12 feeding punctures on the bark. A leaf drop of about 40 per cent was experienced as a result of both spray injury and *Scolytus* feeding.

The methoxychlor-sprayed tree showed no feeding punctures and was alive and healthy at the end of the experiment there being no spray injury whatsoever.

It was interesting to note that in the toxaphene cage the *Scolytus* lived from a few hours to 3 days, the *Saperda tridentata* from one to 7 days, and a small Elaterid 4 days.

In the Marlate cage, the *Scolytus* beetles died within a few hours, twenty-four at the most, while in the unsprayed check the beetles lived in some cases for several days and in one cage were noted feeding three days after introduction.

It might be interesting to call attention to the fact that emergence of adult *Scolytus* was relatively late in Stamford as compared with other localities in the same latitude. The first emergence date in 1949 was New Haven, Connecticut, May 7; the second, Millbrook, New York, May 8; the third, Westport, Connecticut, May 13; the fourth, Stamford, Connecticut, May 16; and May 5, Syracuse, New York, May 19.

While it would be unwise to make definite recommendations on the basis of the three trees used in this small test, it would seem quite apparent, however, that methoxychlor shows definite promise, whereas toxaphene is decidedly inferior and does not compare with DDT for the purpose of elm *Scolytus* control.

LITERATURE CITED

Bromley, Stanley W. 1948. Tests on control of Elm *Scolytus*. JOUR. ECON. ENT. **41**(2): 327.

EASTERN BRANCH PROGRAM.

Forbes Scale as a Major Pest of Peach

S. C. CHANDLER, *Illinois State Natural History Survey*

The notable increase of Forbes scale, *Aspidiotus forbesi* Johnson on apple within a year after the general inclusion of DDT in the spray schedule, has a parallel on peach. The use of DDT on peach for the control of insects causing cat-facing began in 1947 in Illinois, and by 1948 was quite generally included in the spray and dust schedules of peach growers. It was used early for cat-facing control and later for combatting the oriental fruit moth and by some for peach borer control. Fall surveys of San Jose scale, *A. perniciosus* Comstock, over a period of 18 years had shown peaks of high infestation quite regularly every third year followed by sudden drops to a very low level the year after the high point in infestation. Such was not the case, however, in 1948 and 1949, when 63 per cent and 53 per cent respectively of the orchards were found to have moderate to severe infestations in some part of the orchard. Close examination of scale on peach by several of us in the Natural History Survey over the years in connection with control tests had indicated that we were dealing with San Jose scale only.

Although peach has been listed by some authors as a host of Forbes scale, this insect has been considered of such little importance generally on peach that some authors describing the insect have failed to include peach as a host. In November, 1949, samples of scale from heavily infested peach orchards were submitted to one of our systematic entomologists, Mr. Lewis J. Stannard, Jr., for determination. These orchards were located in seven important peach-growing counties of southern Illinois. The report of these eleven samples was as follows:

Forbes scale only, found in six
San Jose scale only, found in two
A mixture of both, found in three

This would seem to place Forbes scale among the important pests of peaches.

Dragon Fly Feeding on Cankerworms

S. W. BROMLEY, *Bartlett Tree Research Laboratories Stamford, Conn.*

In a paper written jointly by Dr. E. P. Felt (Felt & Bromley 1937) I recorded several important predators of the cankerworm (*Alsophila pometaria* Harris). Another and quite unusual enemy of the cankerworm has recently come to light. In late May, 1949, Mr. W. C. Hall and A. F. Winslow, of the Bartlett Tree Expert Company, saw at Monroe, New York, dragon flies seizing cankerworms which were spinning down from infested trees in great numbers. Specimens sent to me proved to be *Tetragoneuria cynosura* Say, a common so-called "mosquito hawk." This is a comparatively small dragon fly possessing relatively large wings and strong and enduring flight. In the Proceedings of the Entomological Society of Washington, Vol. 50, No. 9, Dec. 1948, p. 236, No. 15, I recorded many instances of its feeding on mosquitoes. In late May of the years of 1913, 1914 and 1915 at Southbridge, Massachusetts, I saw this species feeding in great numbers on swarming winged termites, *Reticulitermes flavipes* Kollar.

LITERATURE CITED

Felt, E. P., and S. W. Bromley. 1937. Observations on shade tree insects and their control. JOUR. ECON ENT. **30**(1): 73.

JOURNAL OF ECONOMIC ENTOMOLOGY
Official Organ American Association of Economic Entomologists

Vol. 43 June, 1950 No. 3

Editorial

Controlling Insect Pests Through Their Nutritional Requirements

Much has been said and written about the general field of insect nutrition, and Dr. William Trager of the Rockefeller Institute for Medical Research very effectively reviewed the subject in 1946. However, the broad field of insect physiology and the part accessory growth factors, minerals, enzymes and amino-acids play in insect nutrition and the relation of form determination and fecundity to nutrition are still largely closed books.

Basically, insect nutrition is believed to be similar to that in man and the higher animals, but in some respects it is at variance. In fact, there is definite evidence that we may be able, by stepping up the major and the minor soil minerals and other soil nutritional factors, to produce larger crops providing optimum balanced rations for man and livestock but crops which may prove either distasteful or even harmful to the well-being of some of our insect pests. In other words, there are definite implications that by using modern practices in conserving and rebuilding the fertility of our soils we may be able to reach and control many of our insect pests through their diet or their nutritional needs.

It is a common observation that generally as agriculture ages in any region soil fertility decreases and insects increase. In the past we have explained this as due to environmental factors other than soil nutrition. However some entomological workers, notably the late Dr. J. B. Smith, in his presidential address to this association some fifty years ago, reported striking results in insect control through the use of soil fertilizers. The idea of controlling insects through the soil by altering the nutrient qualities of their food, therefore, is not new.

Insects are an ancient race of animals which appeared on the globe millions of years before man and his immediate progenitors presumably began their existence here. When they first appeared on the earth the chemistry of its surface and the organic life on it were probably not as we find them today. From the fossil records it seems that insects arrived along with land plants of the fungus and lichen type. This was many millions of years ahead of the rise of flowering plants and present-day types of crops which supply much of our food needs. If we can believe the fossil records, insects must have "cut their eye-teeth" figuratively on such diets as present-day fungi and other non-chlorophyl bearing plants would supply. This would mean that in the beginning their diet was probably high in proteins and low in carbohydrates. Insects are today and probably through past ages always were the most adaptive of all animal life to changing foods and shifting climatic conditions. In their long years of schooling in how to adjust their needs to available food supplies they devised many tricks which we and the other higher animals are not able to use. Some of them as we know them today, for instance, are able to thrive best on what to us would be an unbalanced or inferior diet. Also some species are able to synthesize certain of their necessary accessory growth factors.

While insects show remarkable ability to adjust their dietary needs to changing food supplies, those shifts in diet may have marked influence on their well-being, their anatomy and their fecundity. If we are able to control them through their diet it will be largely by reducing their reproductive potential, though it will also help where we are able to affect their physical well-being and such factors, for instance, as wing development.

In nature we have numerous familiar cases of the influence of diet on insect form determination and reproductive potential. Likewise experimentally various workers have been able to duplicate some of the familiar cases seen in nature by

simply varying the diet of the test insects.

The business-like worker honey bee with stunted ovaries is not a normal queen simply because she received a different diet as a grub. Later these sterile adult workers may become egg layers if given the proper diet. Seemingly cast formation in ant and termite colonies is also due to diet.

Wing formation in aphids in the field as well as in the laboratory is due to the chemistry of the plant sap which they consume. It is probably plant nutrition in the fall also that normally shifts them from parthenogenetic reproduction back to normal sexual reproduction. Likewise the length of the wings in certain grasshoppers and crickets has been altered by different workers simply by varying their diet and environment. In nature the long-winged migratory grasshoppers become long-range menaces to agriculture in various parts of the world from time to time, therefore, probably largely due to their diet as influenced by climate.

In the chinch bug we have a major crop pest which has quite definitely been shown to be influenced by the one mineral, nitrogen, in its diet. In nature it passes up the nitrogenous legume crops for the grassy crops which are higher in carbohydrates. It is on the stunted corn, for instance, up on the eroded slopes where it thrives best rather than down on the vigorous plants at the foot of the slopes where soil moisture and fertility provide higher levels of nitrogen in the plant sap. Also the pest thrives best and menaces our crops most in periods of dry years when all crops tend to suffer from lack of soil moisture ladened with soil minerals including the tell-tale nitrogen. Different workers studying the chinch bug under controlled conditions have found that on a diet of corn plants grown in nutrient solutions low in nitrogen it is normally more vigorous, lives longer and lays more eggs than when on a diet high in nitrogen. We have in the chinch bug, therefore, apparently one major pest which we should be able to reach through its diet by stepping up soil fertility.

Another common pest, the greenhouse thrips, has also been shown to be allergic, shall we say, to nitrogen, for when given its choice of New Zealand spinach grown on varying levels of nitrogen and of calcium it practically destroyed the replications on the low nitrogen levels and passed up those on high levels. Those which it passed up were the typical vigorous spinach plants, such as growers produce for human consumption. Here again, therefore, we have a pest which we should be able to influence by stepping up soil fertility.

On the other hand we do run up against some major pests, which, like the cow, seem to choose and require crops grown on highly fertile soil. Generally European corn borer populations are highest on the most fertile, high-yielding soils. However, even here there is much yet to be found out about the chemistry of the corn plant when it is most attractive to and provides optimum diet for this pest. Shifting of the relative levels of the principal soil minerals and the minor elements might conceivably affect the pest unfavorably even on the high yielding soils.

In nature years ago the Colorado potato beetle on shifting its diet from native weeds to potatoes promptly increased in vigor and fecundity. Controlled experiments with the tuber flea beetle have shown substantially the same response when fed on potato as compared with native weeds. These beetles are therefore responsive to diet, and by proper manipulation of soil fertility it is conceivable we may be able to reach and hold them in normal bounds.

Some work with blood-sucking parasites of animals and man shows that variation in blood diet may influence their well-being and reproductive potential. Certain mosquitoes, for instance, lay more eggs when fed on the blood of one animal than when fed on that of another, and the diet may also affect longevity. Scrawny, underfed animals seem to be more attractive to and more heavily infested with lice. The same is apt to be the case with horse bot and ox warble infestations. It is possible therefore that some of the animal parasites, similar to certain crop pests, may thrive better on an inferior diet, and if so the solution should be to build up the vigor of the host and the quality of its blood.

Most of what has been done so far along these lines has been rather exploratory in nature. It is to be hoped that more of you

younger men will interest yourselves in this line of work. The field is wide open and points the way to new, urgent aids to insect control. We must work more with and less against nature, for we are still figuratively mere children crying in the wilderness. Through the wide-spread use of the newer high powered insecticides we have done more to increase the lop-sided balance of nature in connection with insects and agriculture in the last ten years than in the previous one-hundred years. We economic entomologists, in our present unbridled chemical warfare against insects, need to stop and take stock of just where we are headed. If we cannot always succeed in controlling insect pests by working with nature through the soil, we can at least slow down our further drive at destroying her normal balance.

LEONARD HASEMAN

BOOK REVIEWS

LOS NATURALISTAS EN LA AMÉRICA LATINA: Tomo 1, Los Siglos XVI, XVII y XVIII, Alejandro Humboldt, Carlos Darwin, La Española, Cuba y Puerto Rico, by Carlos E. Chardón, pp. 386, pl. 27, Secretaria de Estado de Agricultura, Pecuaria y Colonización, Ciudad Trujillo, República Dominicana, 1949.

Not since the publication of Dr. L. O. Howard's "A History of Applied Entomology (Somewhat Anecdotal)", (Smithsonian Misc. Collections, Whole Volume 84, Publication 3065, pp. 564, pl. 51, Washington, D. C., November 29, 1930) has any connected and complete account appeared of the development to date of entomology (and the other natural sciences) in the West Indies. To be sure, Dr. Chardón is more interested in the systematic aspects of entomology than in its economic advances, but both are critically presented in these biographies of all the noteworthy entomologists who have worked in the Greater Antilles. His volume will be especially welcome to the examiner of candidates for a higher degree who elect Spanish as a foreign language, for this is not a translation, and should prove not only intelligible to the examiner, but of fascinating interest to the budding doctor in natural sciences.

GEORGE N. WOLCOTT

March 27, 1950

THE NATURAL HISTORY OF MOSQUITOES, by Marston Bates. The Macmillan Company, New York. xvi–379 pp., 16 plates, 9 figs., 14 tables. 1949. Price, $5.00.

Dr. Bates, the author of numerous papers covering a wide range of mosquito research, demonstrates in this noteworthy contribution that he knows his subject well. His lucid style of writing, and excellent manner of analyzing, condensing and organizing the vast amount of information should appeal to both the layman and to the scientist. In short, the work is "an attempt at summarizing what is known about the behavior of mosquitoes" from a broad and general biological point of view. It has substantial binding, good format and well selected illustrations, and should serve as a valuable reference for the student, and as an excellent guide for those who desire to go further into the study of this economically important group of insects.

The first twelve chapters are concerned chiefly with the biological phenomena that are associated with and govern the activity of mosquitoes. Individual stages in the life history are treated separately, and the larval and adult stages in particular are linked with the various aspects of their physical and biological environments. Much attention is devoted to the subject of selection of habitats, including classification of environments where eggs are laid and larvae are to be found. The works of many investigators have been summarized in a very orderly and informative way to show the effects of various chemical and physical factors on the behavior of these insects. Chapters XII–XV are concerned almost entirely with the medical aspect, or parasitology. The role that mosquitoes play as parasites and as prey is given proportionate consideration but, justifiably so, most attention is focused on the role these insects play as hosts of other organisms, and particularly as vectors of the causal agents of diseases of humans and other animals. The great amount of information that is assembled in these chapters has to do mostly with the known viruses, and in more detail with the plasmodia which cause the various types of malaria. Entomotropic is a term proposed for mammalian disease producing viruses which have become adapted to insect tissue, and which are dependent on insect hosts for transmission. Chapters XVI–XVIII are of special interest to the taxonomist. The author discusses briefly the subjects speciation and mechanisms of speciation, and presents several interesting examples of mosquito populations to illustrate the reality of the problem. The interesting chapter on classification reflects the author's desire to express what might be termed a reasonable approach to the problem of mosquito nomenclature and classification. Even though the subject could not be discussed at great length, some of the more modern concepts of zoological taxonomy are summarized quite clearly from the publications of several well known contemporary workers in the field of general taxonomy. The author follows the catalogue of mosquitoes by Edwards, who was one of the most noted British dipterists. The adoption of that nomenclature and classification in the present work, which is admittedly not a taxonomic treatment, seems natural because it is less cumbersome and the names employed are generally better understood than, for example, those in the monograph by Theobald, another noted British contributor to the classification of mosquitoes. Since a taxonomic study in itself is beyond the scope of the book, and since the fixing of generic concepts is very much a matter subject to personal opinion among taxonomists—whether to lump species and make larger generic categories as Edwards has done, or to divide the genera and make smaller groups as did Theobald—Dr. Bates has refrained from in-

troducing any nomenclatorial innovations. He has presented an unbiased discussion of the problem and has given some of the advantages of both schools of thought with reference to mosquito classification. The single chapter devoted to the distribution of mosquitoes contains interesting species comparisons of both numbers and kinds between the faunal regions of the world. Chapters XIX–XX deal with techniques and methods employed in mosquito studies and research; they contain much valuable information of practical nature. The appendix is a rather long list of the species referred to in the text, with an indication of the general distribution of each. The bibliography, though not complete by any means, is a sizeable collection of all the most important works on mosquitoes. Because of the broad scope of the subject, it also contains many valuable general references in various other fields of biological science. A notable feature is the page number, or numbers, in brackets following each entry to indicate where it was cited in the text, thus eliminating the necessity of including reference to them in the index proper.

The book is recommended, not only to all entomologists and persons interested in public health, but also to biologists, animal ecologists and physiologists, who should find it both entertaining to read and useful as a reference.

H. E. MILLIRON
Glendale, West Virginia

EXPERIMENTAL DESIGNS, by W. G. Cochran and Gertrude M. Cox. John Wiley & Sons, Inc., New York. 1950. $5.75.

There has been a great advance in application of statistical methods to experimental problems, and experimental design is the culmination of this effort. The best possible use of such methods is in planning experiments beforehand, so that they will give needed comparisons, and use time and money efficiently.

The volume cited above is a valuable summary of progress in this field, with a discussion of use of statistics and detailed accounts of a variety of experimental plans. Results from actual experiments in field and laboratory are used in illustration. A number of designs applicable in entomological problems are described, and results from one entomological field experiment are used in illustration. It is to be hoped that entomologists as well as other scientists will utilize this valuable work.

F. M. WADLEY

NOTES

HENRY BISCHOFF WEISS, D.SC.

Graduate of the University of Pennsylvania in the Class of 1906; now completing forty years of service to the State of New Jersey as Director of Plant Industry in the State Department of Agriculture; one of the early proponents of the application of the quarantine principle against noxious pests of foreign countries; largely responsible for the complete extermination from New Jersey of the gypsy moth and the relegation of the Japanese beetle to a pest of secondary importance; for the past quarter century editor of *The Journal of the New York Entomological Society;* author of several scientific books and more than six hundred articles; recipient of the Gold Medallion of the New Jersey Agricultural Society in 1949.

The above citation accompanied the presentation to Mr. Weiss of the honorary degree of Doctor of Science at the annual commencement of Rutgers University on June 10, 1950.

The editor takes the liberty of extending to Dr. Weiss the congratulations of the membership for this well-deserved recognition of his service to Entomology and to the communities which he has served so long and so well.

Dr. Frank W. Fisk has been appointed to the position of Insect Physiologist and Toxicologist in the Department of Entomology, Ohio State University.

GEORGIA ENTOMOLOGICAL SOCIETY

Forty-three entomologists attended the fourteenth annual spring meeting of the Georgia Entomological Society at Fort Valley, Georgia, on March 3 and 4, 1950. John C. Alden, President, and O. I. Snapp served as the Committee on Local Arrangements. Nine papers were presented and a moving picture on the white-fringed beetle was shown. The Woolfolk Chemical Company, Ltd., of Fort Valley gave the annual dinner free of charge to the Society. Officers for 1950 are G. G. Rowher, Macon, President; T. M. Gunn, Atlanta, Vice-President; and H. O. Lund, Athens, Secretary-Treasurer.

COOPERATIVE VIRUS RESEARCH STARTED

The first annual meeting of the Pacific Coast Small Fruit Virus Conference was held in Portland, Oregon on January 5, 1950. The meeting was attended by virus workers from Experiment Stations in British Columbia, Washington, Oregon and California, in the fields of Horticulture, Plant Pathology, and Entomology, who discussed their related problems. The principal topics were:

1. Strawberry virus complex component segregation studies.
2. The problem of new strawberry varieties to replace the Marshall.
3. Reduction of field virus spread by vector.

Dr. S. W. Simmons, chief of the Technical Development Services, Communicable Disease Center, United States Public Health Service, and the American representative on the World Health Organization Expert Committee on Insecticides, that will meet in Geneva, Switzerland during October, has been appointed chairman of a new committee of the Section on Medical Entomology of the American Association of Economic Entomologists. This new committee will be responsible for assembling the latest information on insecticides of public health importance.

"The 23rd Annual Meeting of the International Great Plains Conference of Entomologists will be held in Banff National Park, Alberta, Canada, on August 31, September 1 and 2, 1950. Information regarding housing reservations, and so forth, may be had by writing to Dr. C. W. Farstad, Field Crop Insect Laboratory, Box 270, Lethbridge, Alberta, Canada." CLARENCE E. MICKEL, *Permanent President.*

RADIOISOTOPES IN ENTOMOLOGY

In the March 15, 1950 issue of "Nucleonics," a journal published by the McGraw-Hill Book Co., Inc., of New York City, there appeared an article by Dale W. Jenkins and Charles C. Hassett, of the Medical Division, Army Chemical Center, Maryland, on the "Use of Radioisotopes in Entomology," that should be of considerable interest to many entomologists. The authors have reviewed the literature on the uses of radioisotopes in entomology and have indicated additional fields for research. Consideration is given to such items as equipment, selection of isotopes, the biological importance of the elements, the rate of decay of radioactive isotopes, the type of emission, and the availability of such isotopes.

This is followed by a discussion of the use of radioisotopes in ecological studies, their use in studying the flight movements of mosquitoes, the dispersal of insects in the soil, the food relationships between organisms, the transmission of plant diseases by insect vectors and various insect-plant relationships. In addition there is the field of the effects of radiation on organisms. Cell division, growth and metamorphosis in insects have all been retarded by high intensities of beta and gamma radiation. Reproduction has been both reduced and enhanced according to recent work but more research is needed on this subject.

At present promising lines of work are developing in physiology and toxicology, involving the use of radioactive materials as tracers in metabolism studies, and in determining the rate of deterioration of soil insecticides. The authors suggest as a desirable goal in insecticide research, an increase in the selectivity of a compound so that more injurious insects could be destroyed while fewer beneficial ones are killed. Another problem involves insects which become resistant to toxic materials. In all such fields radioisotopes are going to play an increasingly important part. A bibliography of 41 titles closes this interesting and stimulating paper about a field that is expanding rapidly and which is destined to play an important part in future entomological research. —H.B.W.

PROCEEDINGS OF THE FIFTH ANNUAL MEETING

NORTH CENTRAL STATES BRANCH, AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Hotel President, Kansas City, Missouri

March 23 and 24, 1950

The Fifth Annual Conference of the North Central States Branch American Association of Economic Entomologists was called to order by President George M. List. President List extended a word of welcome to the 335 persons in attendance and expressed his hope that everyone would find this conference very worthwhile.

The 1950 program consisted of 80 separate topics covering the major insect problems of the North Central States. The various sectional meetings and the respective chairman of each session were as follow:

Sessions	*Chairman*
Insecticides, Residues and Equipment	G. M. List
Insects Affecting Man and Animals	E. Hixson
Truck Crop Insects	T. E. Bronson
Extension Entomology	T. H. Parks
Apiculture	J. A. Munro
Some Fundamental Entomological Problems	G. M. List
Cereal and Forage Crop Insects	C. R. Neiswander
Fruit and Greenhouse Insects	C. R. Cutright

The program for the 1950 meeting was prepared by R. E. Hill, chairman, G. E. Lehker, and D. A. Wilbur.

The Committee on Local Arrangements was composed of Lee Jenkins, chairman, R. C. Smith, R. L. Cuff, C. D. Michener, and R. I. Wakeman.

PRELIMINARY BUSINESS SESSION THURSDAY MARCH 23, 1950

President List appointed the following committee for the 1950 meeting:

Resolutions	*Auditing*	*Time and Place of 1951 Meeting*
T. C. Allen, Chm.	L. L. English	F. G. Holdaway, Chm.
T. R. Brindley	M. H. Muma	P. C. Stone
J. E. Fahey		J. P. Sleesman

R. T. Everly was appointed as Recorder to prepare the 1950 Proceedings.

The Nominating Committee (J. H. Bigger-C. H. Richardson-T. L. Aamodt) was called upon to present their selection of nominees for new officers in the Branch. The following slate was proposed:

For President	*For Vice-President*	*For Secretary-Treasurer*
Ray Hutson	C. J. Weinman	J. W. Apple
C. R. Neiswander	R. E. Hill	A. W. Buzicky

This report of the Nominating Committee was approved by the membership. President List called for further nominations from the floor but none were made before nominations were closed.

President List called for nominations for the new Nominating Committee. The following persons were nominated for the three-man committee:

R. L. Parker
R. H. Painter
E. Hixson
J. A. Munro
R. J. Dicke

President List introduced Dr. C. P. Clausen, President of the American Association of Economic Entomologists, who brought greetings from the Parent Association. Dr. Clausen expressed his gratitude for the opportunity to attend the Branch meeting and he extended an invitation to all those present to attend the National Meetings to be held

in Denver next December. Dr. Clausen reported on the progress being made in the unification of the two entomological societies.

The Branch was quite honored to have the Vice-President of the Parent Association, R. E. Campbell, also in attendance during the 1950 meeting.

BANQUET
THURSDAY MARCH 23, 1950

Some 207 persons attended the 1950 Branch banquet. The banquet address was given by Dean Floyd Andre of the Division of Agriculture, Iowa State College. Dean Andre chose as his topic "It's Inventory Taking Time." This message from one of our most outstanding entomologists in the country was most inspiring. Dean Andre presented an administrator's views on the trends in economic entomology and gave his opinion as to the way in which entomologists can best meet the challenge of the future.

FINAL BUSINESS SESSION
FRIDAY MARCH 24, 1950

The meeting was called to order by President List.

President List called for the following committee reports:

REPORT OF THE RESOLUTIONS COMMITTEE

Resolution No. 1

WHEREAS: the fifth annual meeting of the North Central States Branch of the American Association of Economic Entomologists has completed a most successful session.

Be it Resolved: that an expression of appreciation be extended to the Program Committee, to the discussion leaders, and to the speakers who have devoted their efforts in the preparation and presentation of topics; to the committee on local arrangements; to the participating industries and to the management and employees of the Hotel President for their courteous service and cooperation.

Resolution No. 2

WHEREAS: a greater need exists for a closer relation between the North Central States Branch of the American Association and the Parent Association.

Be it Resolved: that the North Central States Branch of the American Association of Economic Entomologists solicit permission from the Parent Association to be represented at executive committee meetings by a duly selected member of the Branch and that this representative report back to the North Central States Branch at each annual meeting such information pertinent to the organization.

Resolution No. 3

WHEREAS: there has been an expressed desire for a more uniform diction in the pronunciation of newly "coined" common names of new insecticides.

Bet it Resolved: that the North Central States Branch of the American Association of Economic Entomology urge the Committee on Insecticide Terminology of the Association to indicate their preferred pronunciation where possible and for the sake of uniformity, it is urged that all members of the Society adopt such pronunciations if possible.

Resolution No. 4

WHEREAS: the entomologists of the North Central States recognize the need and have expressed the desire for research on the proposed area project, "Causes of Insect Outbreaks."

Be it Resolved: that we the entomologists of the North Central States request that the officers of this Association ask the Directors of the Experiment Stations of the North Central States Colleges, to reconsider and take steps to implement the suggested regional project on the "Causes of Insect Outbreaks" as proposed by the North Central States Technical Committee on Entomology.

Resolution No. 5

WHEREAS: the various extension services within this area of the North Central States have helped with the preparation of the proceedings.

Be it Resolved: that the officers of the executive committee transmit its appreciation for this help and to solicit its continuous cooperation.

Resolutions Committee
T. C. ALLEN, *Chairman*
T. R. BRINDLEY
J. E. FAHEY

All resolutions accepted unanimously by membership.

TREASURER'S REPORT
MARCH 23, 1949 TO MARCH 22, 1950

Credits		
Balance in Treasury—March 23, 1949	$ 331.56	
Sale of 356 copies of Proceedings @$2.00	712.00	
Surplus during 1949 registration	3.00	
From Am. Assoc. Econ. Ent. (For 1949 meeting expenses)	100.45	
Total	$1,147.01	$1,147.01
Debits		
Expenses for 1949 meeting	$ 52.27	
Expenses of Sec'y.-Treasurer at 1949 meeting	28.54	
Paid to U. of Wisconsin for mimeographing paper	1.46	
Paid to Democrat Letter Shop for mailing letter to membership	65.84	
Paid to Miss Dorothy Brockman for secretarial help	$ 14.00	
Cost of preparing 1949 Proceedings	514.10	
Paid to Democrat Letter Shop for mailing letter	56.33	
Paid to U. S. Post office for stamps	6.00	
Total	$ 738.54	$ 738.54
Balance on hand March 22, 1950		$ 408.47

J. W. APPLE, *Secretary-Treasurer*

The books of the Treasurer have been examined by the Auditing Committee and found in order.

L. L. ENGLISH
MARTIN H. MUMA
3/24/50

Treasurer's and Auditing Committee reports accepted unanimously by membership.

REPORT OF THE COMMITTEE ON TIME AND PLACE FOR 1951 MEETING

Your committee on Time and Place for the 1951 meeting has considered various possibilities. The constitution states "on alternate years the annual meeting shall be held near the center of the North Central States group. Other years it may be held at some point nearer the periphery of the area." It is our understanding that the executive committee would not interpret the constitution too strictly.

Although Kansas City is somewhat west of central it appears sufficiently near central to permit of the next meeting being held in the eastern part of the North Central States region. In view of the warm invitation from the State of Michigan and moreover, in view of the fact that the next meeting of the National Association is to be held in the west at Denver, Colorado, and moreover in view of the fact that it is over twenty years since the North Central States Entomologists met in Michigan, it is recommended that the place of the 1951 meeting be at East Lansing, Michigan, second choice Toledo, Ohio.

Michigan State College expects to have their new Continuing Education Building with 192 hotel rooms with twin beds available. The alternative choice of Toledo has been made in case the Branch is not able to secure the Michigan facilities as planned.

Regarding time, we have tentatively selected March 21 and 22 dates which are suitable both to Michigan and Ohio.

We have consulted with the Chairman of the Plant Board and other members of the Board regarding their meeting Monday and Tuesday prior to the Branch meeting. Such dates are acceptable to those members of the Plant Board who have been approached.

F. G. HOLDAWAY, *Chairman*
J. P. SLEESMAN
P. C. STONE

Report of Time and Place Committee accepted unanimously by membership.

(Note—Before going to press, word has been received that the 1951 meetings will be held at East Lansing, Michigan on *Wednesday* and *Thursday* March 21 and 22, 1951.)

J. H. Bigger was called on to give the results from the two elections. The three persons elected to the New Nominating Committee were R. H. Painter, E. Hixson, and J. A. Munro. Mr. Bigger then announced the names of the new officers for the Branch.

C. R. NEISWANDER—*President*
C. J. WEINMAN —*Vice-President*
J. W. APPLE —*Secretary-Treasurer*

President-Elect Neiswander was asked to come to the rostrum to take over the direction of the Branch. Dr. Neiswander expressed his thanks for being honored with the Presidency of the Branch and he asked for continued cooperation from the members during the coming year.

Meeting adjourned by President Neiswander.

OBITUARIES

Paul E. Telford

Paul E. Telford died at Culver City, California, on January 29, 1950, of a lingering heart condition. He was born at Idaho Falls, Idaho, May 12, 1922; he completed his primary and secondary education in this city. He attended Utah State Agricultural College, receiving the B.S. degree in Entomology in June 1946. Following this he studied entomology at Ohio State University, receiving his M.S. degree in 1948. He married Alice Gailey in 1945 and they had a son, John Wm. Telford, three years old. Paul worked on bee investigations for the Utah Agricultural Experiment Station during the summer of 1944 and 1945, and for the U. S. Public Health Service in 1946, in Utah, and for the California State Public Health Department during 1949. His field of particular interest was mite taxonomy and collecting bird parasites. Just before his death he was planning on further graduate study at one of the Universities in the Los Angeles area.

G. F. KNOWLTON
Logan, Utah.

Willard G. Bemis

The passing of Willard G. Bemis on March 2, 1950, represents a distinct loss to the Division of Foreign Plant Quarantines which he has served so efficiently and loyally for in excess of 29 years. Graduating from Massachusetts Agricultural College in 1915 with the degree of B.S., his first assignment with the Bureau of Entomology and Plant Quarantine (then Federal Horticultural Board) was during the period May 1, 1916 to September 30, 1916, at which time he worked on white pine blister rust eradication. From October 1, 1916 to January 1917 he served as nursery inspector of the Massachusetts State Department of Agriculture. From December 10, 1917 to July 31, 1919 he was in the Army and spent much of the time overseas as a First Lieutenant. On August 4, 1919 he was appointed as a scientific assistant of the Bureau of Entomology and stationed in Arlington, Massachusetts, where he remained until December 4, 1919, at which time he was transferred to the Federal Horticultural Board (eradication of the pink bollworm project) with headquarters at Houston, Texas. On October 16, 1920 he was transferred to Boston, Massachusetts, to assist the late Ralph I. Smith in the work there, and upon Mr. Smith's death on February 26, 1927 he succeeded him as Inspector in Charge of the port of Boston where he remained until September 1, 1937, at which time he was made Principal Assistant to the Inspector in Charge at the port of New York. Much of the time that he was on this assignment he was acting in charge due to absence of the Inspector in Charge. His last assignment was that of Supervisor of the Canadian Border District, which he took over on December 22, 1942, and successfully managed until his death.

To illustrate his keen interest in the work under his supervision, he proceeded to Cleveland, Ohio on the night of February 27, 1950, to confer with the customs officials and spent the entire day of February 28 clearing a backlog of mail of plant quarantine interest, returning to New York that night and proceeding directly to the office, even though he was not feeling well, on March 1. The following day he passed on.

In addition to the esteem in which he was held by his fellow workers, Mr. Bemis had the respect of the Customs and Post Office officials, and, as the result of this respect, a splendid spirit of cooperation was developed in the district under his supervision. His genial smile made him a welcome visitor, and his sincerity inspired the confidence of his associates and the public with whom he came in contact. It is men such as Willard Bemis that have made the Division a success.

E. R. SASSCER

REPRINTS WITH COVERS

Common Names of Insects—This is the list of names approved by the American Association of Economic Entomology.

Indispensable for all working entomologists.

Price: 50¢ each. Send remittance to,

E. N. CORY, Business Manager
American Association of Economic Entomologists
University of Maryland
College Park, Maryland

ENTOMA

A Directory of Pest Control Materials . . .

• • Eighth Edition now available for distribution.

• • Listing insecticides, fungicides, seed disinfectants, spray machinery, trade names, pest control operators, etc.

• • Designed to aid those interested in pest control in obtaining certain information which is often difficult of access.

• • Know where to purchase pest control materials.

• • Published by the Eastern Branch of the American Association of Economic Entomologists.

Price $1.50—Make check to Entoma

Write to

George S. Langford, Editor
University of Maryland
College Park, Md.